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NASA Contractor Report 3256

The NASA/MSFC Global Reference Atmospheric Model - MOD 3 (With Spherical Harmonic Wind Model)

C. G. Justus, G. R. Fletcher,
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MARCH 1980

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C. G. Justus, G. R. Fletcher,
F. E. Gramling, and W. B. Pace
Georgia Institute of Technology
Atlanta, Georgia

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and Space Administration

Scientific and Technical
Information Office

1980

FOREWORD

The effort required to develop the Global Reference Atmospheric Model was sponsored by the Atmospheric Sciences Division, Space Sciences Laboratory, NASA Marshall Space Flight Center. This report represents the latest developmental work on the model and was accomplished under the technical monitorship of Mr. Orvel E. Smith, the NASA Contracting Officer's Representative. Qualified requestors may obtain copies of the computer program for this NASA/MSFC Global Reference Atmospheric Model upon request to the Chief, Atmospheric Sciences Division, Space Sciences Laboratory, NASA, Marshall Space Flight Center, Alabama 35812.

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1. INTRODUCTION

In response to needs for empirical model atmospheres of wider scope and application, Georgia Tech developed, under NASA sponsorship, a Global Reference Atmosphere Model (GRAM) with latitude, longitude, and monthly variations over a height range from 0 to 700 km (Justus, et al., 1974 a, b, 1975, 1976). This report describes additions to this model whereby winds can be computed from a spherical harmonic model, based on observed wind data, rather than using the geostrophic relations originally employed. This section describes the basic GRAM model and Section 3 provides a more detailed description of the GRAM program. Section 3 presents some sample results with the new spherical harmonic wind model. Section 4 and 5 are user's manual and programmer's manual section for the GRAM program.

1.1 Description of the Basic Model

The Georgia Tech Global Reference Atmospheric Model (GRAM), is an amalgamation of two previously existing empirical atmospheric models for the low (<25 km) and high (>90 km) atmosphere, with an empirical latitude-longitude dependent model for the middle atmosphere. The high atmospheric region above 115 km is simulated entirely by the Jacchia (1970) model. The Jacchia program sections are in separate subroutines so that later Jacchia models (Jacchia, 1971) or other thermospheric-exospheric models could easily be adapted and substituted into the program if required for special applications. The atmospheric region between 25 km and 115 km is simulated by a latitude-longitude dependent empirical model, which is a modification of the latitude dependent empirical model developed by Groves (1971), described more fully in this report. Between 90 km and 115 km, a smooth transition between the modified Groves values and the Jacchia values is accomplished by a fairing technique. Below 25 km the atmospheric parameters are computed by a 4-D world-wide atmospheric model developed for NASA by Allied Research Associates (Spiegler and Fowler, 1972). Between 25 and 30 km an interpolation scheme is used between the 4-D results and the modified Groves values. Figure 1.1 presents a schematic summary of the Global Reference Atmospheric Model program atmospheric regions and how they are modeled.

The modifications to Groves model to produce longitude as well as latitude variations in the monthly mean were accomplished in two steps. For the original version, upper air summary map data for monthly means at the 10 mb level for 1966 and 1967 (NOAA, 1969b) and the 2 and 0.4 mb levels for 1966, 1967, and 1968 (NOAA, 1969a, 1970, 1971) were read and converted to values for the 30, 40, and 52 km levels. These upper air map values at the 2 and 0.4 mb levels were extended around the entire northern hemisphere by subjective extrapolation. For the earlier Mod 2 version of GRAM, additional 10 mb data for 1964 and 1965 (NOAA, 1967a) and 2 and 0.4 mb data for 1964 and 1965 (NOAA, 1967 b, c) and 1972 (NOAA, 1975) were also read and added to the earlier data. The 1972 2 and 0.4 mb data extended into the eastern hemisphere, so no extrapolation of it was necessary. Next the 30, 40, and 52 km latitude-longitude dependent values were extrapolated to 90 km by an extrapolation scheme developed by Graves, (1973). All of the map-generated and extrapolated data were converted to percent deviation from the longitudinal mean and these are applied as deviations (called stationary perturbations) to the Groves model values, which are taken as the latitude dependent longitudinal means.

The seasonal variations in the middle atmosphere (25-115 km) are assumed to be the same in northern and southern hemispheres with a six months' phase

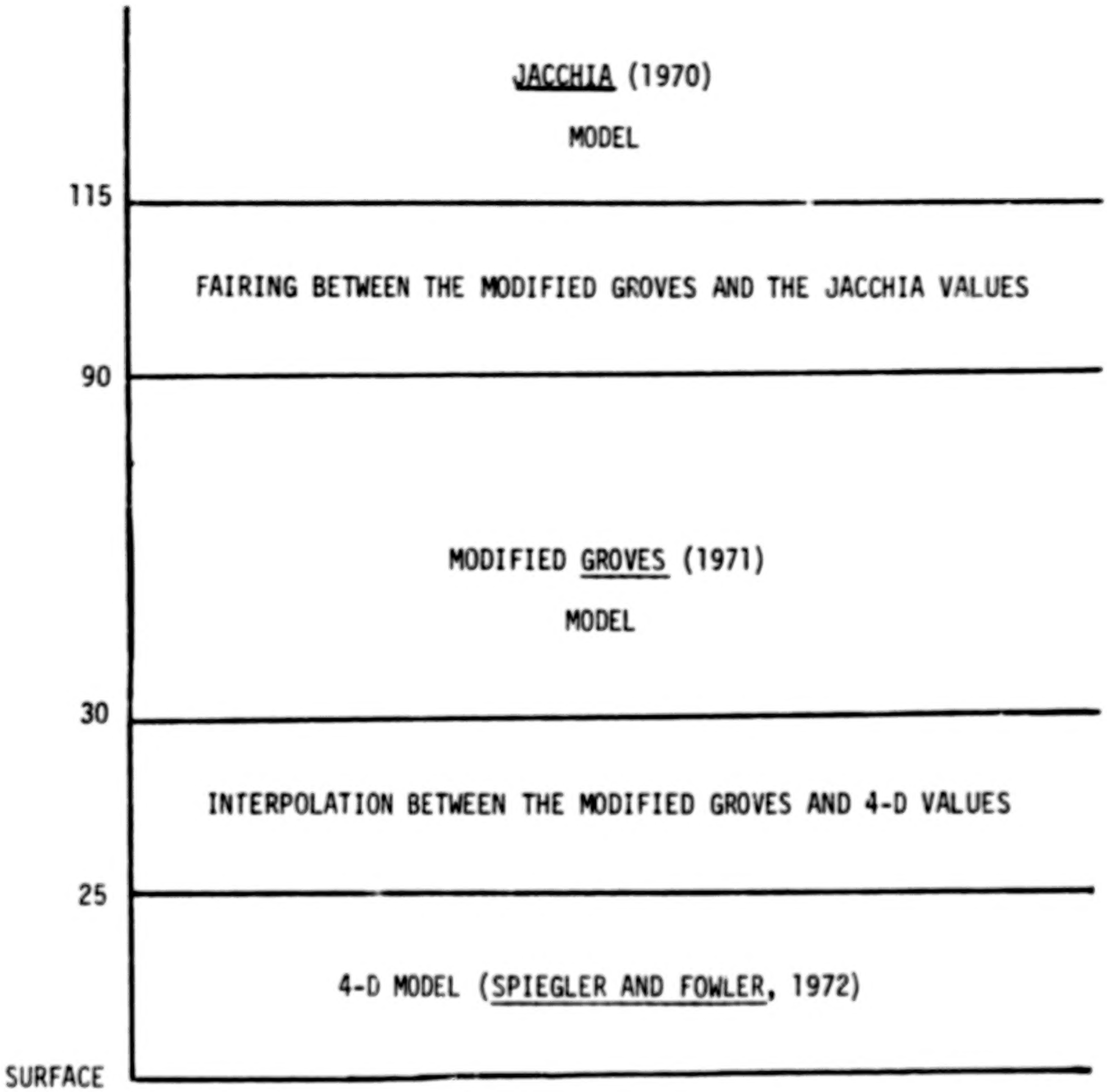

JACCHIA (1970)
MODEL
115
FAIRING BETWEEN THE MODIFIED GROVES AND THE JACCHIA VALUES
90
MODIFIED GROVES (1971)
MODEL
30
INTERPOLATION BETWEEN THE MODIFIED GROVES AND 4-D VALUES
25
4-D MODEL (SPIEGLER AND FOWLER, 1972)
SURFACE

Figure 1.1 Schematic summary of the atmospheric regions in the Global Reference Atmospheric Model (GRAM) program and the simulation methods used for mean monthly values in each region

lag. That is, the southern hemisphere July is the same as the northern hemisphere January. In the 4-D region ($\leq$25 km) separate global coverage data values are available for each of the twelve months. A set of annual reference period data are also available for the 4-D and modified Groves regions. If the annual reference period is selected, the Jacchia section sets the exospheric temperature to 1000°K to represent annual mean conditions.

Below 25 km and above 90 km, the monthly mean geostrophic winds are computed from horizontal pressure gradients, estimated by finite differences. Near the equator, a newly devised interpolation scheme is used instead of the geostrophic relation (which approaches infinite values as the latitude approaches zero). In the height range 25 to 90 km, the newly developed spherical harmonic wind model is used, at all latitudes. Mean vertical winds, of the order of 1 cm/sec, are evaluated from the slopes of isentropic surfaces and the horizontal advective winds. Wind shear in the monthly mean horizontal wind is estimated from horizontal temperature gradients in the regions below 25 km and above 90 km. In the 25-90 km height range, mean wind shear is computed from finite differences of the spherical harmonic winds at adjacent height levels.

In addition to the monthly mean values of pressure, density and temperature, two types of perturbations are evaluated: quasi-biennial (QBO) and random. The QBO oscillations in pressure, density, temperature, and winds, empirically determined to be represented by an 870 day period sinusoidal variation, have amplitudes and phases which vary with height and latitude. The QBO amplitudes are primarily significant at low altitudes (≈ 20 - 40 km) at equatorial latitudes and at higher altitudes (50 - 60 km) at higher latitudes. For the earlier Mod 2 version, the QBO amplitudes and phases were newly evaluated from a larger data set, which included MRN data through 1972.

For realistic simulation of actual atmospheric parameter values as they would likely be at any given time, random perturbations are also computed and applied as perturbations to the monthly mean values. The random perturbations are evaluated by a simulation technique which uses empirical values of variation magnitudes and scales to generate random perturbations which have realistic space and time correlations.

Originally the perturbation model was characterized by a single vertical scale and horizontal scale, and no attempt was made to insure compliance with constraints on the perturbation magnitudes, required by the perfect gas law (Buell, 1970) and hydrostatic equation (Buell, 1972). In an earlier report (Justus and Woodrum, 1975), the revisions were described which improved the data base of the perturbation magnitudes, and adjusted the magnitude profiles to insure compliance with the Buell constraints. For the earlier Mod 2 version reported here, the use of a two scale perturbation model was implemented. This model simulates separately the perturbations of small scale (e.g., turbulence and gravity waves) and large scale (e.g., tides and planetary waves) effects. These perturbations are treated stochastically, however--no deterministic model of these physical processes is used.

The following sections give a technical description of the Global Reference Atmospheric Model - Mod 3 with emphasis on the new additions, and new users manual descriptions of the program aspects of the revised model.

2. TECHNICAL DESCRIPTION OF THE MODEL

2.1 The Jacchia Section

The Jacchia (1970) model for the thermosphere and exosphere was originally implemented to compute atmospheric density at satellite altitudes. The Jacchia model accounts for temperature and density variations due to solar and geomagnetic activity, diurnal and semi-annual variations, and seasonal and latitudinal variations. The Jacchia model assumes a uniformly mixed composition from sea level to 105 km, with diffusive equilibrium among the constituents (nitrogen, oxygen, argon, helium, and hydrogen) above 105 km. Fixed boundary values for temperature and density are assumed at 90 km. Alterations, described in Justus et al (1974 a), were made to allow atmospheric pressure to be computed from the density and temperature. Geostrophic winds are evaluated in the Jacchia section by computing horizontal pressure gradients with successive evaluations of the Jacchia model at different latitudes and longitudes.

2.2 The 4-D Section (below 25 km)

The 4-D atmospheric model, developed by Allied Research Associates (Spiegler and Fowler, 1972) was designed to extract from data tapes and interpolate on latitude and longitude, mean monthly and daily variance profiles of pressure, density, temperature. at 1 km intervals from the surface to a height of 25 km for any location on the globe. The data tapes contain empirically determined atmospheric parameter profiles at a large array of locations. The northern hemisphere grid array is equivalent to the NMC grid network. Grids spaced at 5 degree intervals of latitude and longitude are used in the equatorial and southern hemisphere regions.

Technical changes made in the 4-D program were: a modified latitude-longitude interpolation method, previously described in Justus et al. (1974 a), an adjustment routine to modify the variance to comply with the Buell constraints, and a check routine to determine vertical and horizontal consistency of the 4-D data.

The method of application of the 4-D model in the GRAM program is as follows: at the first time that atmospheric parameters at a location below 30 km are required, a set of atmospheric profiles of monthly mean and daily variances of pressure, density, and temperature are generated at a 16 point grid of locations spaced at 5 degree latitude and longitude intervals (a slightly different grid is used near the poles). This grid of profiles, covering 15° x 15° of latitude-longitude is then stored in the computer and all further atmospheric parameter values in the 0-25 km range are found by interpolation between locations within this grid. If the trajectory goes outside this grid while the height remains below 25 km, the program attempts an estimate of the atmospheric parameters by an additional call on the routine which sets up the 4-D data grid.

The location of the grid points to be evaluated is determined dynamically based on the position and direction of travel along the trajectory when the 4-D grid is first required by a procedure described in Justus et al (1974 a). The 4-D data tapes normally contain data for the surface to 25 km in 1 km steps. At locations where the surface is at more than 1 km above sea level the surface value will be followed by one or more zero records, and the first non-zero record above the surface value will be at the lowest integer km higher than the surface. For example, if the surface is at 700 m then there will be data at surface, 1 km, 2 km, etc., but if the surface is at 1.3 km the data will contain the surface, one zero record, 2 km, 3 km, etc. In the Mod-3 version an interpolation routine (based on the hydrostatic relation and constant lapse rate altitude segments) is used to fill in data between sea level and the first non-zero data above the surface. Interpolation is also used to fill in any missing data immediately below the 25 km height. The basic interpolation equations were described in Justus et al (1974 a).

2.3 The Modified Groves Section (25 - 90 km)

The starting point for the middle atmosphere (25 - 110 km) is the latitude dependent model of Groves (1971). This empirical model combines many observations from a wide range of longitudes. Observational results over approximately six years were used to compute longitudinal averages, which are presented versus latitude and month. Latitude coverage of the Groves model is from the equator to 70° or in some cases 80°. Southern hemisphere data were utilized in developing the Groves model as northern hemisphere data with a 6-month change of date. Tabulations of the Groves model are at intervals of 5 km in height, 10° in latitude (northern hemisphere), and one month in time (southern hemisphere displaced six months). If the Groves values of an atmospheric parameter y were known up to 80° latitude, then the 90° latitude Groves value was computed from

$$y_{90} = (4y_{80} - y_{70})/3 \tag{2.1}$$

If Groves values of the atmospheric parameter y were known only up to 70° latitude, then the 80° and 90° latitude Groves values was computed from

$$y_{90} = (9y_{70} - 4y_{60})/5 \tag{2.2}$$

$$y_{80} = (8y_{70} - 3y_{60})/5 \tag{2.3}$$

The Groves model data has only height and latitude variation for each month. For longitude variation, the Groves model data is modified by longitude, latitude, and height dependent stationary perturbations. These stationary perturbations are derived, by methods described more fully in Justus et al (1974 a) from 10, 2, and 0.4 mb map data and extrapolation up to 90 km. The stationary perturbations were evaluated at longitudes 10°, 40°, 70°, ... 340° for latitudes 10°, 30°, 50°, 70°, and 90°.

Originally, only the 1966 and 1967 10 mb monthly mean values (NOAA, 1969 b) were read and averaged. The 2 mb and 0.4 mb weekly mean maps for 1966, 1967, and 1968 (NOAA, 1969 a), 1970, 1971) were read for the first week of each month, and averaged over the three years. For the earlier Mod 2 version, additional 10 mb data for 1964 and 1964 (NOAA, 1967 a) and 2 and 0.4 mb data for 1964 and 1965 (NOAA, 1967 b, c) and 1972 (NOAA, 1975) were also read and added to the earlier data.

After the upper air chart data were averaged, the next step was to convert the readings to constant heights of 30, 40, and 52 km. This was done by assuming that the temperature followed a constant lapse rate between each chart level and the nearest interpolation altitude with lapse rates based on the Groves model.

In order to introduce longitude variability at heights above 52 km, the extrapolation technique of Graves et al. (1973) was used to project the 52 km interpolated chart data up to 90 km. The 5 extrapolation height levels are 60, 68, 76, 84, and 90 km.

After the chart data were interpolated to 30, 40, and 52 km and extrapolated to 60, 68, 76, 84, and 90 km, the stationary perturbations (relative deviations to be added to the Groves values) were calculated. At each altitude and latitude the stationary perturbation s_y for a parameter y (which can represent pressure, density, or temperature) was computed by the relation

$$s_y = (y - \langle y \rangle)/\langle y \rangle \tag{2.4}$$

where $\langle y \rangle$ represents the longitude averaged value of y (i.e. averaged around a circle of fixed latitude). Note that the definition of s_y makes it be identically zero at the pole. The stationary perturbation s_y for parameter y is added to the Groves value G_y to produce the longitude variable modified Groves value G'_y, according to the relation

$$G'_y = G_y(1 + s_y) \tag{2.5}$$

The modified Groves values, determined by relation (2.5) are used as the monthly mean values for the altitude range 30 to 90 km.

2.4 Interpolation and Fairing

The 4-D data are available on the data tapes at one km height intervals and at 5° x 5° latitude-longitude grids in the southern and equatorial areas and at the NMC grid locations in the northern hemisphere. NMC grid profiles are always converted (by interpolation) to 5° x 5° grids before interpolation to the trajectory locations. The general interpolation requirements for the 4-D section are height interpolation over 1 km and latitude-longitude interpolation over a 5° x 5° square grid.

The Groves data are tabulated at 5 km height intervals and 10° latitude intervals. Interpolation is required between these tabulated locations. The stationary perturbations are evaluated at 20° latitude and 30° longitude intervals and at 30, 40, 52, 60, 68, 76, 84, and 90 km altitudes. Interpolation between these tabulated locations is also required. For values between 25 km and 30 km interpolation between the 4-D data and Groves-plus-stationary-perturbation data are required. The interpolations are always carried out in the program by doing the latitude (Groves) or latitude-longitude (4-D) interpolation first, and then doing the height interpolation.

The Jacchia model can be evaluated at any height above 90 km and at any latitude and longitude, so no interpolation is required. However, between 90 and 115 km there is overlap between the Groves data and the Jacchia model, so a fairing procedure is used to effect a smooth transition between the Groves data at 90 km and the Jacchia values at 115 km.

The method used to interpolate pressure, density, and temperature over a height interval between heights z_1 and z_2 is to assume linear variation of the temperature and of the logarithm of the density. The latitude interpolation for the Groves data is done by assuming linear variation between the latitudes ϕ_1 and ϕ_2 (which are at $\Delta\phi = 10°$ apart). Two dimensional latitude-longitude interpolation between a square or rectangular array of positions at latitudes ϕ_1 and ϕ_2 and west longitudes λ_1 and λ_2, is done by the relation

$$F(\phi , \lambda) = F_o + (F_1 - F_o)\delta\phi + (F_2 - F_o)\delta\phi + (F_3 - F_1 - F_2 + F_o)\delta\phi \ \delta\lambda$$

where $\delta\phi$ is $(\phi - \phi_1)/(\phi_2 - \phi_1)$ and $\delta\lambda$ is $(\lambda - \lambda_1)/(\lambda_2 - \lambda_1)$.

To accomplish smooth transition between the Groves values at 90 km and the Jacchia values at 115 km a fairing technique is used. This fairing technique was described in Justus et al (1974 a). The fairing is done only at the altitudes 95, 100, 105, 110, i.e. heights for which there are Groves values. Linear interpolation is then used to fill in the remaining heights, as discussed in the height interpolation section above.

Interpolation of the random perturbation magnitudes is done linearly on the variance (σ^2) rather than linearly on the magnitude (σ). This is because the Buell adjustment equations (see later sections) are nearly linear in the variances. Thus, once variances have been Buell adjusted, their adjustment would tend to be preserved by linear interpolation on variances, not magnitudes.

2.5 Geostrophic Winds

The eastward (i.e., blowing toward the east) wind component u and northward component v can be evaluated from the geostrophic wind equations

$$u = -(1/\rho f)\ \partial p/\partial y \tag{2.6}$$

$$v = (1/\rho f)\ \partial p/\partial x \tag{2.7}$$

where ρ is the density, f is the Coriolis parameter ($2\ \Omega \sin \phi$) and $\partial p/\partial x$ and $\partial p/\partial y$ are the eastward and northward components of the horizontal pressure gradient. For evaluation in the model, the pressure gradient terms must be approximated by finite differences.

Geostrophic wind values are computed in the 4-D height range, by finite differencing of the 4-D pressure data, and in the Jacchia height range by evaluating the Jacchia model at 5 degree increments of latitude and longtitude and taking finite differences of the resulting pressure. In a recent comparison between the GRAM-computed winds and observed winds at Eglin AFB, Florida, the mean deviation was 1 m/s EW and -16 m/s NS, with an rms deviation of 60 m/s between model and observed. Thus, the mean winds are modeled with fair accuracy, and the rms deviation is about the same as the wind perturbation magnitude expected on the basis of the GRAM perturbation model.

2.6 Thermal Wind Shear

The wind shear components $\partial u/\partial z$ and $\partial v/\partial z$ in the 0-25 km and above 90 km height ranges are evaluated by the thermal wind equations

$$\partial u/\partial z = -(g/fT)\ \partial T/\partial y \tag{2.8}$$

$$\partial v/\partial z = (g/fT)\ \partial T/\partial x \tag{2.9}$$

which is the usual form, leaving off a correction term in $\partial T/\partial z$, which is normally small. The horizontal temperature gradient terms are estimated by finite differences in a similar manner to the pressure gradient components in equations (2.6) and (2.7).

Thermal wind shears are also computed in the Jacchia height range in a manner similar to that described for the wind calculations. Again, however, for the reasons already discussed, these values should not be taken as precise.

Since the ordinary geostrophic winds are inversely proportional to the coriolis parameter f (which goes to zero at the equator), these relations give unrealistically large winds at low latitudes. To overcome this problem interpolation between about +15° and -15° latitude is used in the MOD-3 version of GRAM. This interpolation limit, being on the "minimum geostrophic latitude," is specified in the program input.

2.7 The Spherical Harmonic Wind Model

The spherical harmonic equation, including terms through second order in co-latitude (ϕ) and longitude (θ), are:

$$\begin{aligned} u(m, z, \theta, \phi) = {} & a_1 P_0(\mu) + a_2 P_1(\mu) \\ & + [a_3 \cos\theta + a_4 \sin\theta] P_{11}(\mu) + a_5 P_2(\mu) \\ & + [a_6 \cos\theta + a_7 \sin\theta] P_{21}(\mu) \\ & + [a_8 \cos 2\theta + a_8 \sin 2\theta] P_{22}(\mu) \end{aligned} \tag{2.10}$$

where $\mu = \cos\phi$, m is month, z is height, u is either the wind component being modeled, and the a coefficients all depend on both m and z. The $P_{ij}(\mu)$ are Legendre functions given by

$$
\begin{aligned}
P_0(\mu) &= 1 \\
P_1(\mu) &= \mu \\
P_2(\mu) &= (3\mu^2-1)/2 \\
P_{11}(\mu) &= (1 - \mu^2)^{1/2} \\
P_{21}(\mu) &= 3\mu(1 - \mu^2)^{1/2} \\
P_{22}(\mu) &= 3(1 - \mu^2)
\end{aligned}
\tag{2.11}
$$

With the substitution of (2.11) into (2.10), the spherical harmonic model representation for a wind component becomes

$$
\begin{aligned}
u(m, z, \theta, \phi) = {} & a_1 + a_2 \cos\phi + a_3 \cos\theta \sin\phi \\
& + a_4 \sin\theta \sin\phi + a_5(3 \cos^2\phi - 1)/2 \\
& + a_6 \cos\theta \, (3 \sin\phi \cos\phi) + a_3 \sin\theta \, (3 \sin\phi \cos\phi) \\
& + a_8 \, (2 \cos^2\theta - 1) \, (3 \sin^2 \phi) + a_9 \, (2 \sin\theta \cos\theta) \, (3 \sin^2\phi)
\end{aligned}
\tag{2.12}
$$

If (2.12) is the representation of the eastward wind component, then a completely analogous equation, with different coefficient values, is used to represent the northward wind component. Appendix A describes the data and processes used to evaluate the spherical harmonic coefficients which are used in the GRAM MOD-3. Values of the spherical harmonic coefficients used in the program are given in the "SCIDAT" data tape listing, in Appendix B.

Spherical harmonic winds are computed at all latitudes, within the height range 25-90 km. Geostrophic winds are used at latitudes above a selected "minimum geostrophic latitude," over the height ranges 0-20 and above 90. Smooth fairing between spherical harmonic winds and geostrophic winds is carried out between 20 and 25 km and between 90 and 95 km.

2.8 Mean Vertical Winds

GRAM also evaluates mean vertical winds from the slope of isentropic surfaces. On such surfaces, the entropy function ψ is constant, where ψ is

$$\psi = C_pT + gz + (u^2 + v^2)/2 = \text{const.} \tag{2.13}$$

Therefore, on isentropic surfaces

$$\partial\psi/\partial t + u\partial\psi/\partial x + v\partial\psi/\partial y + w\partial\psi/\partial z = 0 \tag{2.14}$$

and, if $\partial\psi/\partial t$ is assumed zero, the vertical wind w can be solved for as

$$w = -[u\partial\psi/\partial x + v\partial\psi/\partial y]/(\partial\psi/\partial z) \tag{2.15}$$

By differentiation of (2.13), with the assumption that u and v are the geostrophic winds u_g and v_g, and that $\partial u/\partial z$ and $\partial v/\partial z$ are given by the thermal wind relations, (2.15) becomes

$$w = -C_p\,[u_g(\partial T/\partial x) + v_g(\partial T/\partial y)]/$$
$$\{g + C_p(\partial T/\partial z) + (g/fT)[v_g(\partial T/\partial x) - u_g(\partial T/\partial y)]\} \tag{2.16}$$

Mean vertical winds evaluated by (2.16) are generally less than a cm/sec, and hence are realistic values for the large scale mean vertical winds affecting mean meridional circulation.

2.9 The Quasi-Biennial Perturbations

In the Mod-0 Global Reference Atmospheric Model, MRN data from 1964-1969 were used to evaluate quasi-biennial amplitudes and phases in the height range 25-65 km. The quasi-biennial period which produce minimum variance, when simultaneously evaluating the annual, semi-annual, and quasi-biennial variation, was found to be 870 days. For the Mod 2 version, the harmonic analysis was done the same way with MRN data for 1970-1972 added to the original data base. Again, the 870 day period was found to produce minimum variance for the QBO winds, while a 900 day period did slightly better for the thermodynamic variables. In order to retain a single period, the original 870 day period was chosen as still the preferable value overall. The revised quasi-biennial magnitudes and phases are listed in the "SCIDAT" data tape listing at the end of this report (Appendix B).

2.10 The Two-Scale Random Perturbation Model

The original single scale perturbation model in the Global Reference Atmosphere Model (Justus et al., 1974 a) was evaluated by the following method: first the density perturbation ρ_2' at the new location was computed from ρ_1' the density perturbation at the previous location by the relation

$$(\rho_2'/\bar{\rho}_2) = A(\rho_1'/\bar{\rho}_1) + Br_1 \qquad (2.17)$$

where $\bar{\rho}_1$ and $\bar{\rho}_2$ are the known mean densities at the previous and new positions, A and B are determined from the required conditions, and r_1 is a random number selected from a Gaussian distribution with mean zero and unit standard deviation. The required conditions to be used in determining A and B are

$$<\rho_2' \rho_1'> = R\, \sigma_{\rho 1}\, \sigma_{\rho 2} \qquad (2.18)$$

$$<\rho_2'^2> = \sigma_{\rho_2}^{\;2} \qquad (2.19)$$

where $\sigma_{\rho 1}$ and $\sigma_{\rho 2}$ are the known standard deviations in density at the previous and new location, and R is the known autocorrelation in density perturbations between the previous and new locations. Next (with analogous notation as in (2.17) through (2.19), the new temperature perturbation was computed by

$$(T_2'/\bar{T}_2) = C(T_1'/\bar{T}_1) + D(\rho_2'/\bar{\rho}_2) + Er_2 \qquad (2.20)$$

In addition to the autocorrelation R (assumed the same for T' and ρ' in the original one-scale model) the cross correlation $(R_{\rho T})_2$ was also maintained (through the coefficient D in equation (2.20)). The correlation $(R_{\rho T})_2$ was determined from the known standard deviations and means by the Buell (1970) relation

$$(R_{\rho T})_2 = \frac{[(\sigma_p)_2/\bar{p}_2]^2 - [(\sigma_\rho)_2/\bar{\rho}_2]^2 - [(\sigma_T)_2/\bar{T}_2]^2}{2[(\sigma_\rho)_2/\bar{\rho}_2]\,[(\sigma_T)_2/\bar{T}_2]} \qquad (2.21)$$

Once the density and temperature perturbations were evaluated, the pressure perturbation was determined via

$$(p_2'/p_2) = (\rho_2'/\bar{\rho}_2) + (T_2'/\bar{T}_2) \qquad (2.22)$$

which is a first order perturbation equation from the perfect gas law. In the original single scale perturbation model, wind perturbation components u' v' were assumed to be uncorrelated with each other and with the thermodynamic variables, and hence were computed by relations analagous to equation (2.17).

In the original one-scale model, only the total perturbations are considered (e.g. $\rho = \bar{\rho} + \rho'$) while in the new two scale model the perturbations are assumed to be made up of a large scale and small scale component (e.g. $\rho = \bar{\rho} + \rho_L + \rho_S$). To first order in the perturbations the state of the mean atmosphere is described by

$$\bar{p} = \bar{\rho}\, R\, \bar{T} \qquad (2.23)$$

and the mean plus large scale perturbations by

$$(\bar{p} + p_L) = (\bar{\rho} + \rho_L)\, R(\bar{T} + T_L) \qquad (2.24)$$

and the actual atmospheric parameters p, ρ, and T by

$$p = \rho\, R\, T \qquad (2.25)$$

Division of equations (2.24) and (2.25) by $\bar{p}$ on the left and by $\bar{\rho}\, R\, \bar{T}$ on the right yields, to first order in the perturbations

$$p_L/\bar{p} = (\rho_L/\bar{\rho}) + (T_L/T) \tag{2.26}$$

$$p_s/\bar{p} = (\rho_s/\bar{\rho}) + (T_s/\bar{T}) \tag{2.27}$$

These results mean that the small scale and large scale perturbations each separately must obey the Buell triangle relationships for their magnitudes. Thus, analogous to equation (2.21), the correlations $R_{\rho_L T_L}$ for large scale perturbations and $R_{\rho_s T_s}$ for small scale perturbations are given in terms of their respective magnitudes by

$$R_{\rho_L T_L} = \frac{(\sigma_{p_L}/\bar{p})^2 - (\sigma_{\rho_L}/\bar{\rho})^2 - (\sigma_{T_L}/\bar{T})^2}{2(\sigma_{\rho_L}/\bar{\rho})(\sigma_{T_L}/\bar{T})} \tag{2.28}$$

$$R_{\rho_s T_s} = \frac{(\sigma_{p_s}/\bar{p})^2 - (\sigma_{\rho_s}/\bar{\rho})^2 - (\sigma_{T_s}/\bar{T})^2}{2(\sigma_{\rho_s}/\bar{\rho})(\sigma_{T_s}/\bar{T})} \tag{2.29}$$

The large and small scale components are assumed to be independent so correlations such as $R_{\rho_s T_L}$, $R_{\rho_L T_s}$ etc. are taken to be zero.

The density perturbations ρ_{L_2} and ρ_{s_2} at the new position are thus computed from the known perturbations ρ_{L_1} and ρ_{s_1} at the previous position by relations analogous to equation (2.17)

$$(\rho_{L_2}/\bar{\rho}) = A_L(\rho_{L_1}/\bar{\rho}_1) + B_L r_{L_1} \tag{2.30}$$

$$(\rho_{s_2}/\bar{\rho}) = A_s(\rho_{s_1}/\bar{\rho}_1) + B_s r_{s_1} \tag{2.31}$$

where A_L, B_L, A_s and B_s can each be determined (as before) from the conditions

$$<\rho_{L_2}\rho_{L_1}> = R_L(\rho)\,\sigma_{\rho L_2}\sigma_{\rho L_1} \tag{2.32}$$

$$<\rho_{L_2}^2> = \sigma_{\rho L_2}^2 \tag{2.33}$$

$$<\rho_{s_2}\rho_{s_1}> = R_s(\rho)\,\sigma_{\rho s_2}\sigma_{\rho s_1} \tag{2.34}$$

$$<\rho_{s_2}^2> = \sigma_{\rho s_2}^2 \tag{2.35}$$

where the density autocorrelations $R_L(\rho)$ and $R_s(\rho)$ are determined from the known horizontal and vertical scale of the large scale and small scale perturbations (see the following section on scales). Similarly, the temperature perturbations are computed (analogous to equation (2.20) by

$$(T_{L_2}/\bar{T}_2) = C_L(T_{L_1}/\bar{T}_1) + D_L(\rho_{L_2}/\bar{\rho}_2) + E_L r_{L_2} \tag{2.36}$$

$$(T_{s_2}/\bar{T}_2) = C_s(T_{s_1}/\bar{T}_1) + D_s(\rho_{s_2}/\bar{\rho}_2) + E_s r_{s_2} \tag{2.37}$$

where again D_L and D_s are determined by the required cross correlations $R_{\rho_s T_s}$ and $R_{\rho_L T_L}$ at the new position, as computed from equations (2.28) and (2.29). Once the density and temperature perturbations are computed, the pressure perturbations are evaluated from equations (2.26) and (2.27).

A further addition to the new model has been brought about by empirically evaluated correlations $R_{u_L v_L}$, $R_{u_s v_s}$, $R_{u_L \rho_L}$, and $R_{u_s \rho_s}$. The new method of evaluating the velocity perturbation components is somewhat analogous to that employed for the temperature component. The equations used are

$$u_{L_2} = F_L u_{L_1} + G_L \rho_{L_2} + H_L r_{u_L} \tag{2.38}$$

$$u_{s_2} = F_s u_{s_1} + G_s \rho_{s_2} + H_s r_{u_s} \tag{2.39}$$

and

$$v_{L_2} = I_L v_{L_1} + J_L u_{L_2} + K_L r_{v_L} \tag{2.40}$$

$$v_{s_2} = I_s v_{s_1} + J_s u_{s_2} + K_s r_{v_s} \tag{2.41}$$

where the coefficients G_L and G_s are determined from the newly evaluated correlations $R_{u_L \rho_L}$ and $R_{u_s \rho_s}$, and the coefficients J_L and J_s are evaluated from the correlations $R_{u_L v_L}$ and $R_{u_s v_s}$.

For evaluation of the coefficients C, D, and E in (2.36) and (2.37), and the coefficients F through K in (2.38) through (2.41), these equations are successively multiplied through by the perturbation quantities on the right-hand side (see Appendix B in Justus et al, (1974 a)). The relations thus established for the coefficients A through K (with analogous equations for both large scale A_L - K_L and small scale A_s - K_s) are

$$A = R(\rho)\, \sigma_{\rho_2}/\sigma_{\rho_1} \tag{2.42}$$

$$B = \sigma_{\rho_2}[1 - R^2(\rho)]^{1/2} \tag{2.43}$$

$$C = [R(T)\, \sigma_{T_2}/\sigma_{T_1}]\, \{[1 - R_{T_2\rho_2}\, R_{T_1\rho_1}]/ [1 - R^2(T)\, R^2_{T_1\rho_1}]\} \tag{2.44}$$

$$D = [R(T)\, \sigma_{T_2}\sigma_{T_1} - C\sigma^2_{T_1}]/(A\, R_{T_1\rho_1}\, \sigma_{T_1}) \tag{2.45}$$

$$E = [\sigma^2_{T_2} - C^2\, \sigma_{T_1}{}^2 - D^2\sigma_{\rho_2}{}^2 - 2\, C\, D\, R(T)\, R_{T_1\rho_1}\, \sigma_{T_1}\, \sigma_{\rho_2}]^{1/2} \tag{2.46}$$

$$F = (\sigma_{u_2}/\sigma_{u_1})\, \{[R(u) - R(\rho)\, R_{u_2\rho_2}\, R_{u_1\rho_1}]/ [1 - R^2(\rho)\, R^2_{u_1\rho_1}]\} \tag{2.47}$$

$$G = (R(u)\ \sigma_{u_2} - F\ \sigma_{u_1}]/[R(\rho)\ R_{u_1\rho_1}\ \sigma_{\rho_2}] \tag{2.48}$$

$$H = [\sigma_{u_2}^{\ 2} - F^2\ \sigma_{u_1}^{\ 2} - G^2\ \sigma_{\rho_2}^{\ 2} -$$
$$2\ F\ G\ R\ (\rho) R_{u_1\rho_1}\ \sigma_{\rho_2}\ \sigma_{u_1}]^{1/2} \tag{2.49}$$

$$I = (\sigma_{v_2}/\sigma_{v_1})\ \{[R(v) - R(\rho)\ R^2_{v_2\rho_2}\ R_{v_1\rho_1}]/$$
$$[1 - R^2\ (\rho)\ R_{v_1\rho_1}]\} \tag{2.50}$$

$$J = [R(v)\ \sigma_{v_2} - I\ \sigma_{v_1}]/[R(\rho)\ R_{v_1\rho_1}\ \sigma_{\rho_2}] \tag{2.51}$$

$$K = [\sigma_{v_2}^{\ 2} - I^2\ \sigma_{v_1}^{\ 2} - J^2\ \sigma_{\rho_2}^{\ 2} -$$
$$2\ I\ J\ R\ (\rho)\ R_{v_{1\rho_1}}\ s_{\rho_2}\ \sigma_{v_1}]^{1/2} \tag{2.52}$$

where the autocorrelations of density R (ρ), temperature R(T) and wind R(u) (R(u) and R(v) are assumed equal), are determined from the horizontal and vertical scales L_{Z_ρ}, L_{H_ρ}, L_{Z_T}, L_{H_T}, L_{Z_u} and L_{H_u} by the relations

$$R(\rho) = \exp\ \{ - [(\Delta x^2 + \Delta y^2)/L^2_{H_\rho} + \Delta z^2/L^2_{Z_\rho}\ ]^{1/2}\} \tag{2.53}$$

$$R(T) - \exp\ \{ - [(\Delta x^2 + \Delta y^2)/L^2_{H_T} + \Delta z^2/L^2_{Z_T}]^{1/2}\} \tag{2.54}$$

$$R(u) = \exp\ \{ - [(\Delta x^2 + \Delta y^2)/L^2_{H_u} + \Delta z^2/L^2_{Z_u}]^{1/2}\} \tag{2.55}$$

3. SAMPLE RESULTS

The ability of the GRAM program to model pressure, density, and temperature fields has been well documented in earlier reports (Justus, et al., 1974 a, b, 1975, 1976). The results shown here are confined to the new spherical harmonic wind model simulations of wind components in the 25 to 90 km height range. Figures 3.1 through 3.12 show observed and spherical harmonic model winds at three low-latitude sites (Kwajalein, Ft. Sherman and Ascension) at mid-latitude and high-latitude northern hemisphere sites (Kennedy SFC, and Ft. Churchill, respectively) and at a southern hemisphere site (Woomena), for the months of June and December. In all cases, the spherical harmonic model winds are seen to reproduce fairly well the features at the observed winds.

Data sources and methods used to evaluate the spherical harmonics appear in Appendix A. The spherical harmonic coefficient values are given in the SCIDAT tape listing in Appendix B.

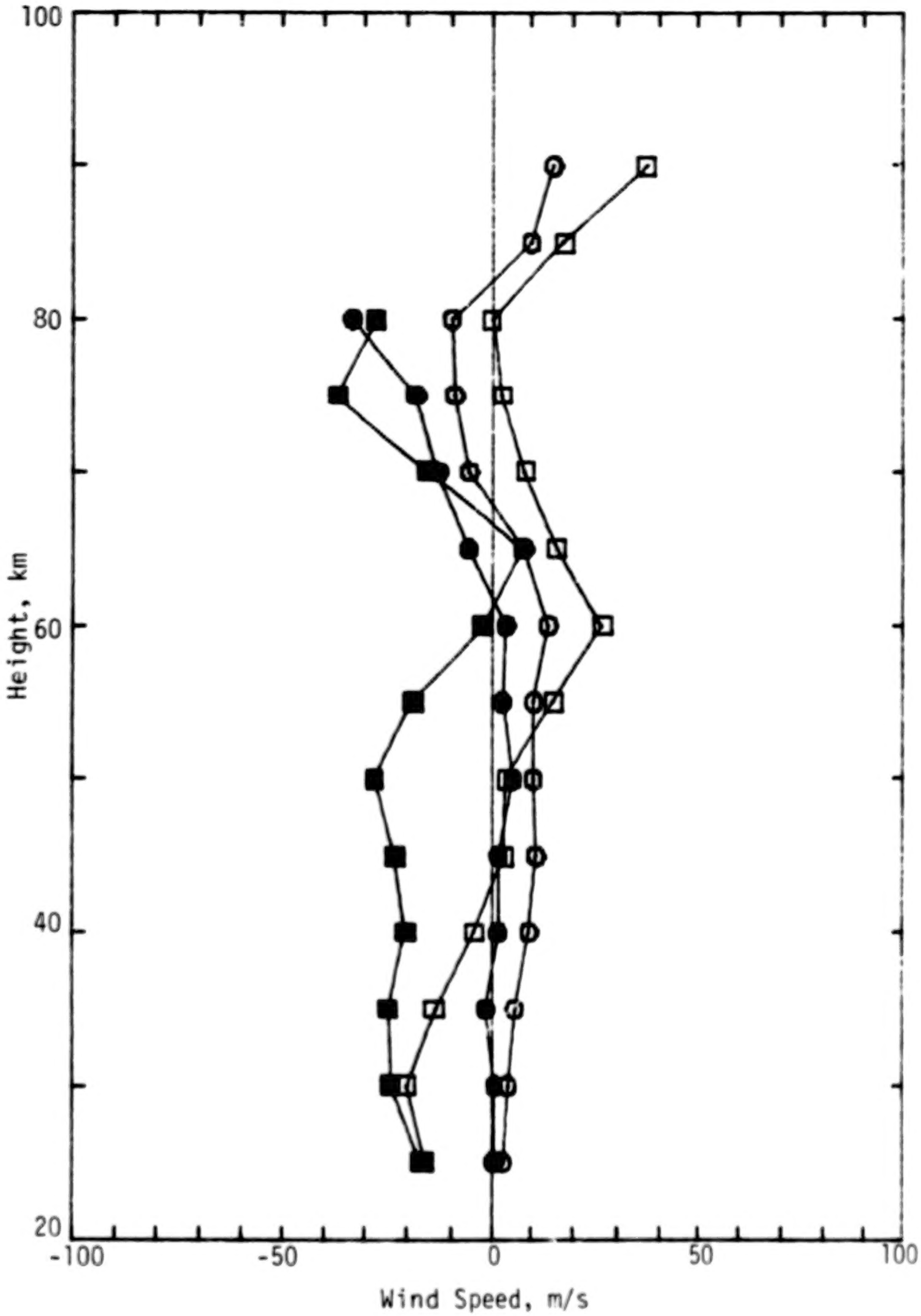


Figure 3.1. Observed (■ E-W, ● N-S) and Spherical Harmonic Model (☐ E-W, ○ N-S) Winds for June at Kwajalein.

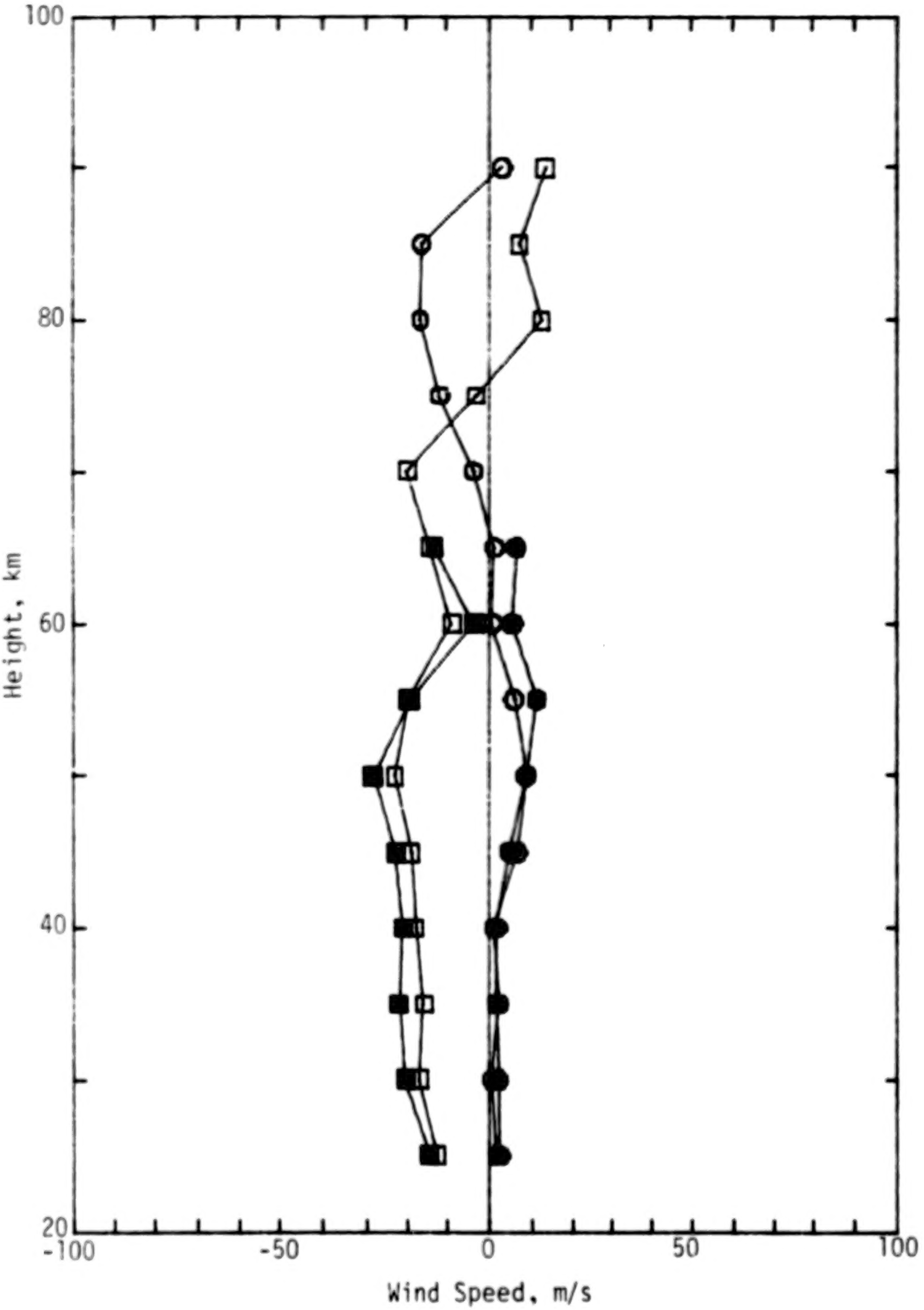


Figure 3.2. As in Figure 3.1 for Fort Sherman

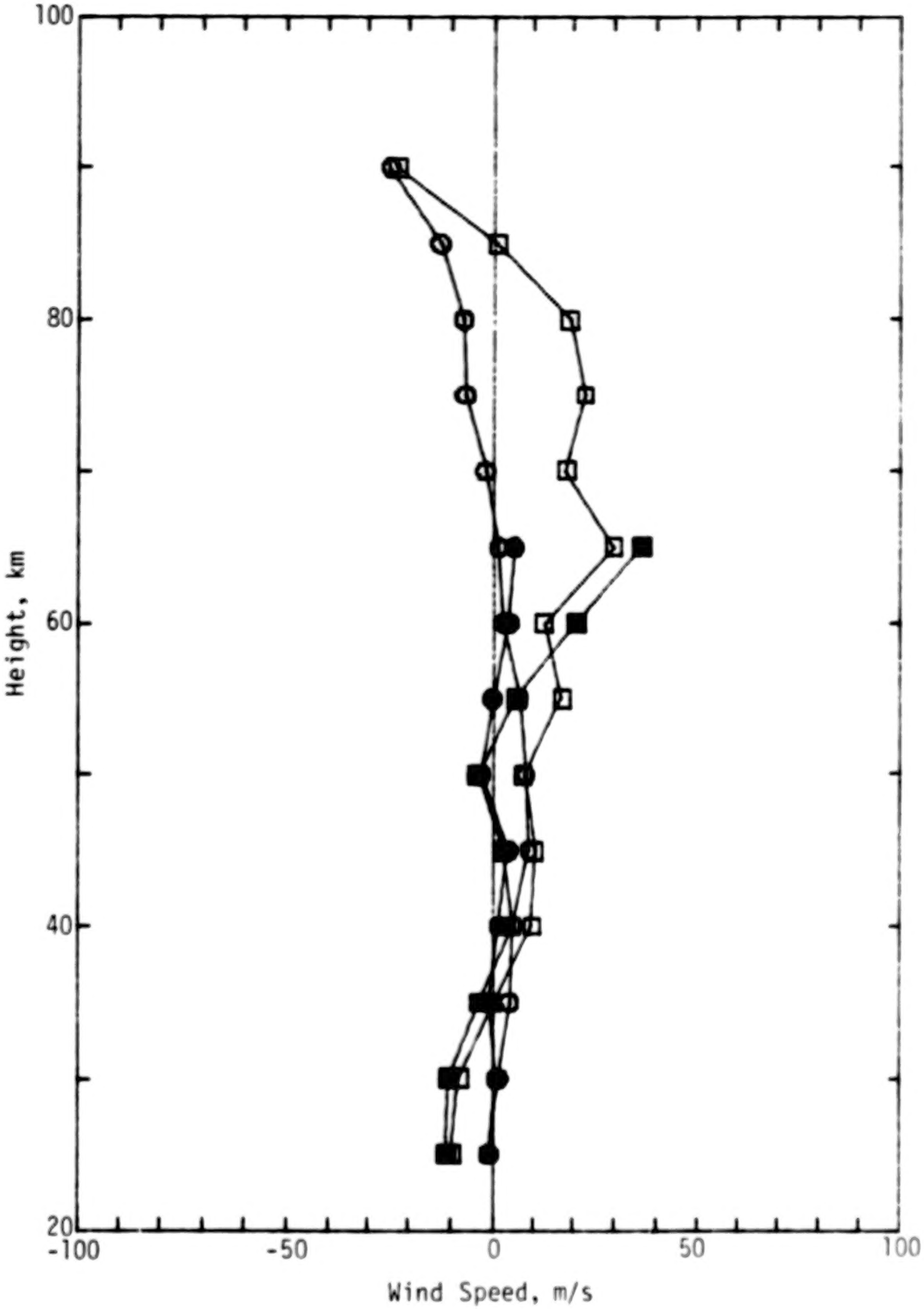


Figure 3.3. As in Figure 3.1 for Ascension.

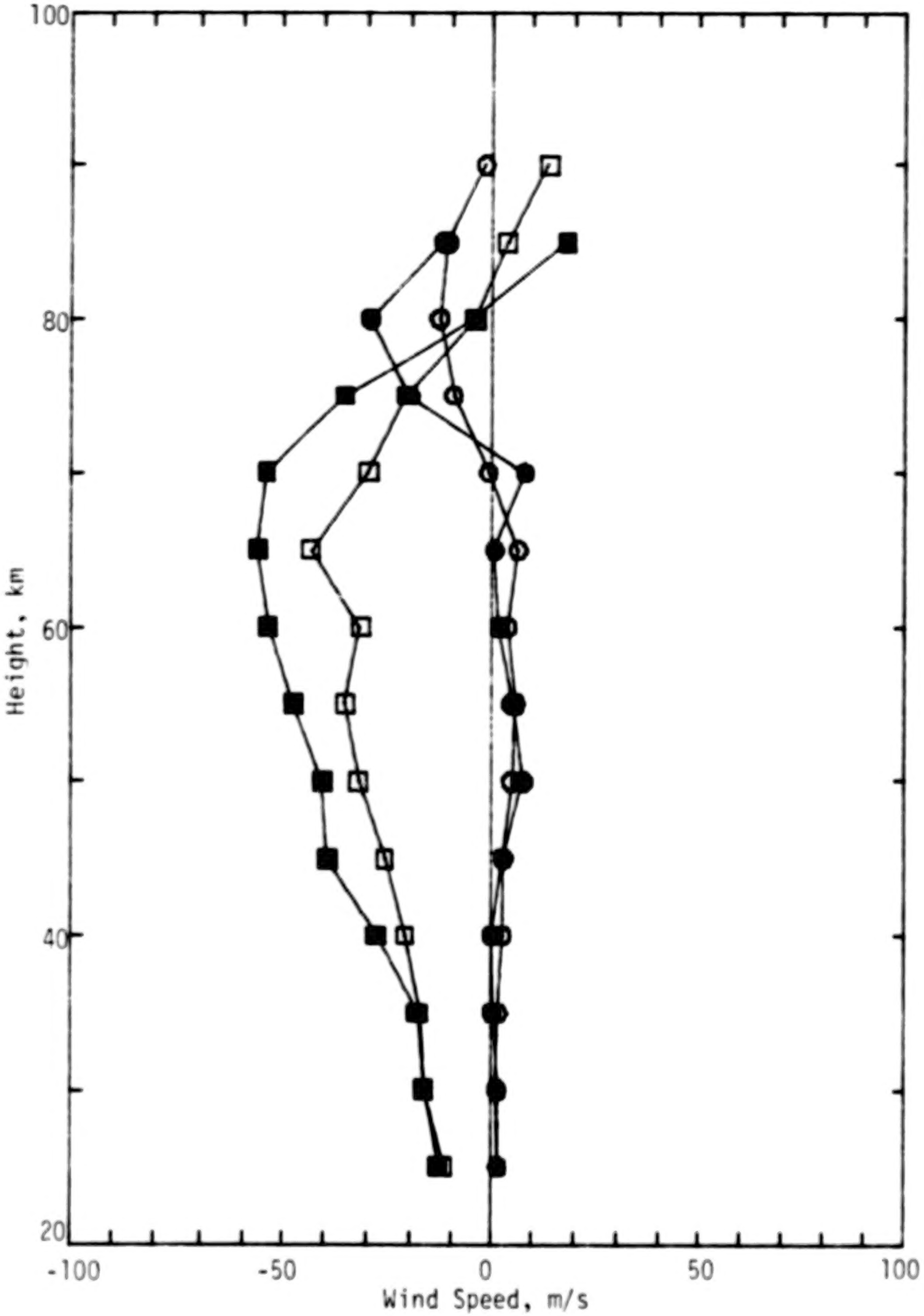


Figure 3.4. As in Figure 3.1 for Kennedy SFC.

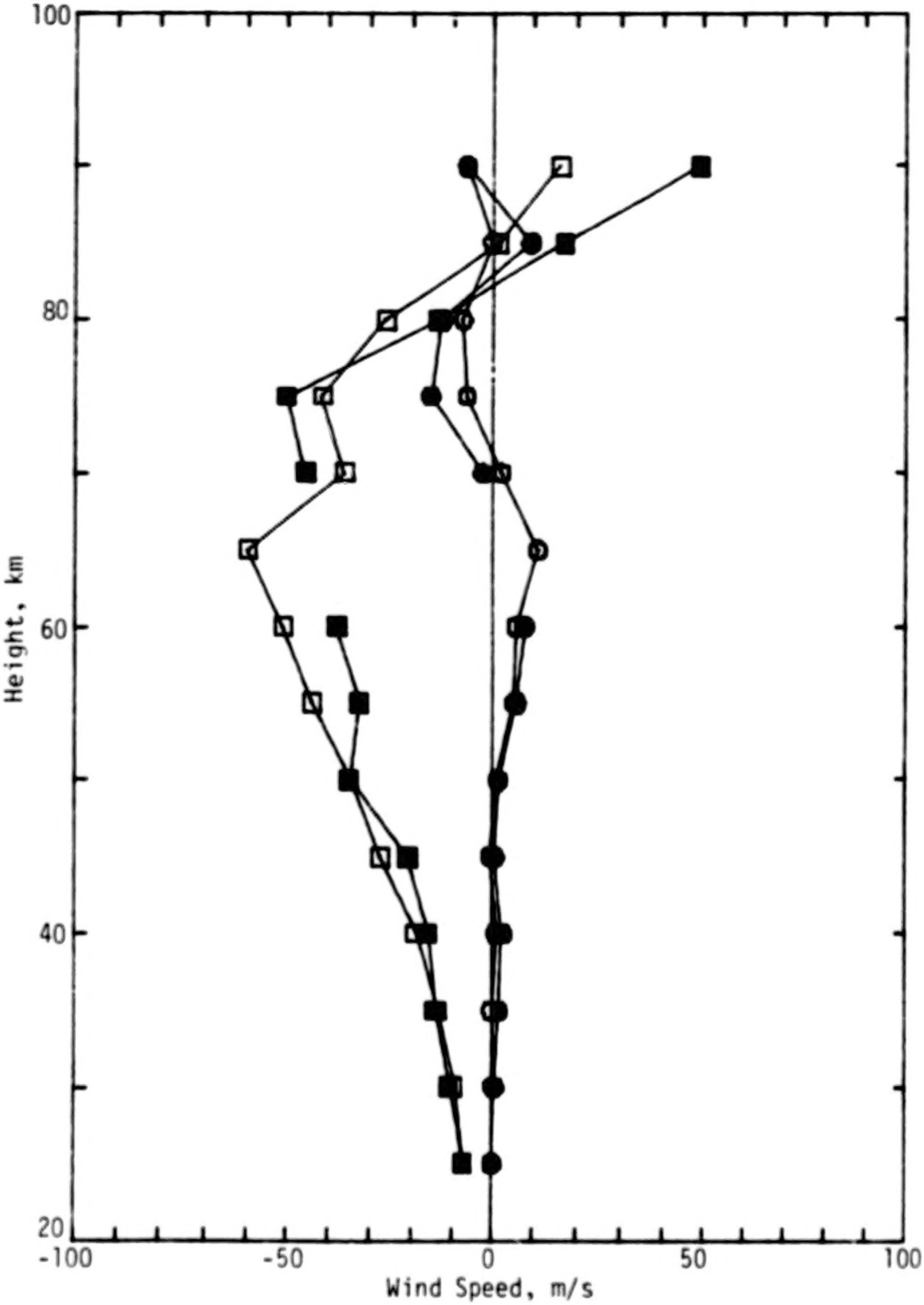


Figure 3.5. As in Figure 3.1 for Fort Churchill.

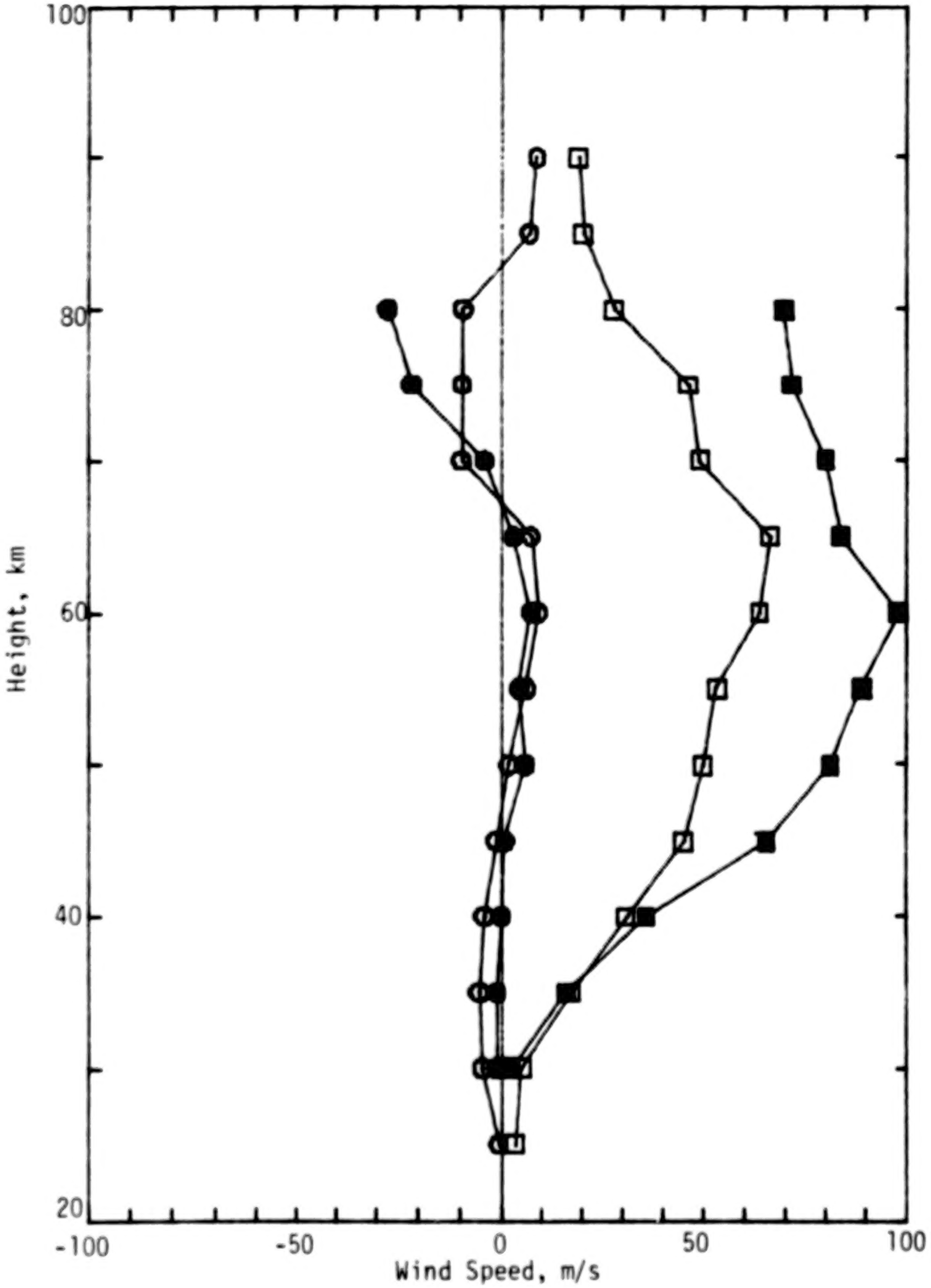


Figure 3.6. As in Figure 3.1 for Woomera.

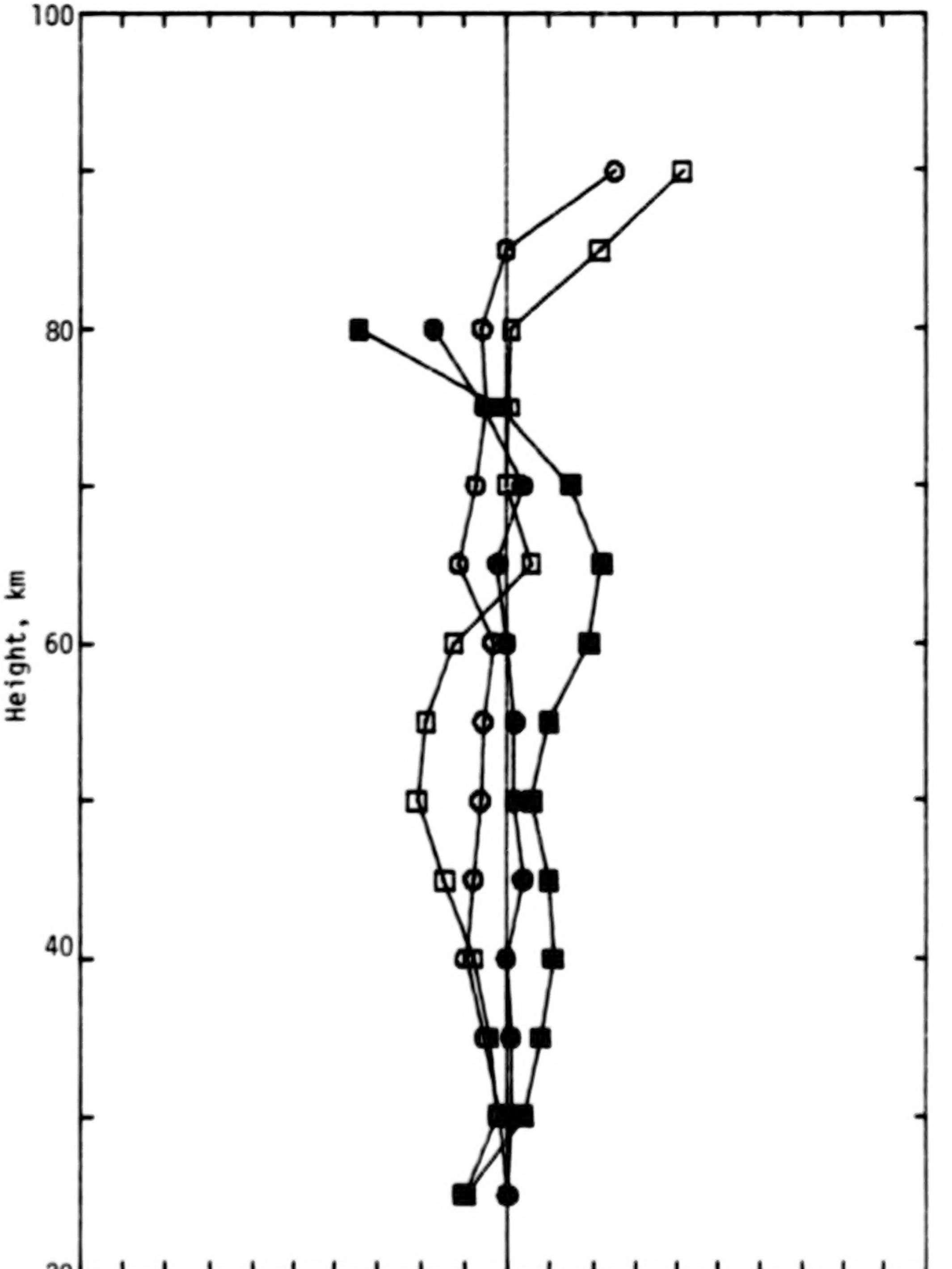


Figure 3.7. As in Figure 3.1 for December, Kwajalein.

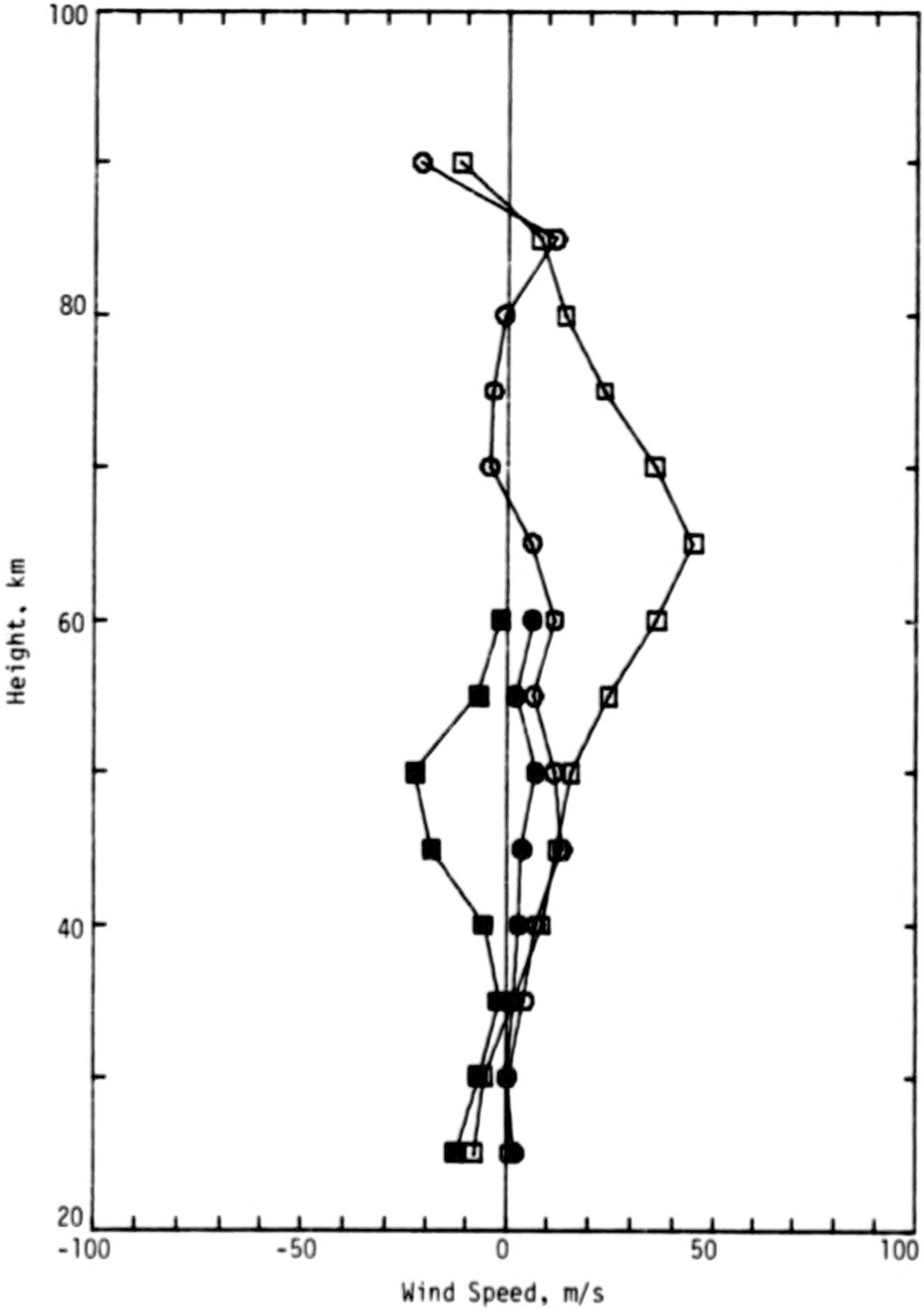


Figure 3.8. As in Figure 3.1 for December, Fort Sherman.

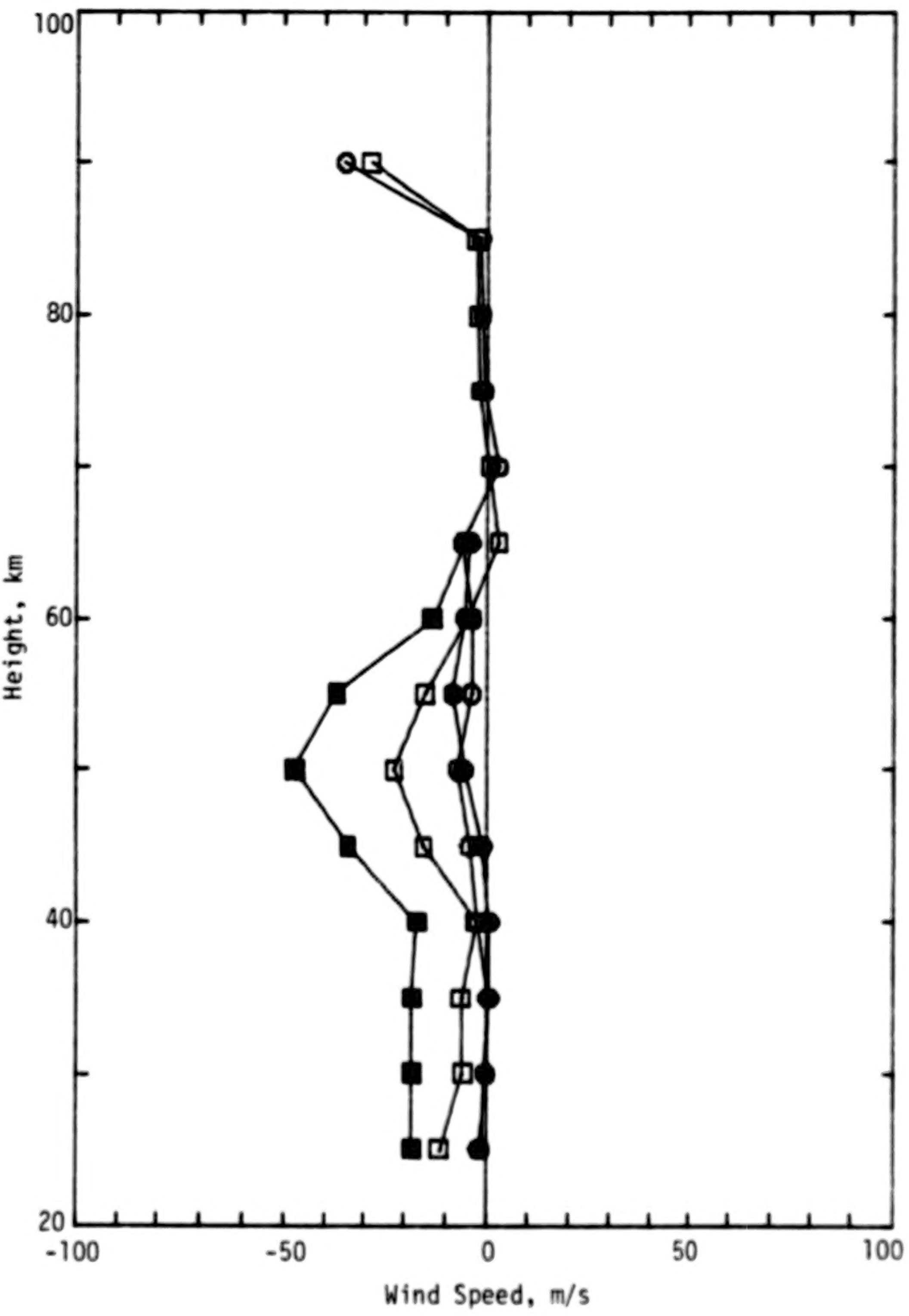


Figure 3.9. As in Figure 3.1 for December, Ascension.

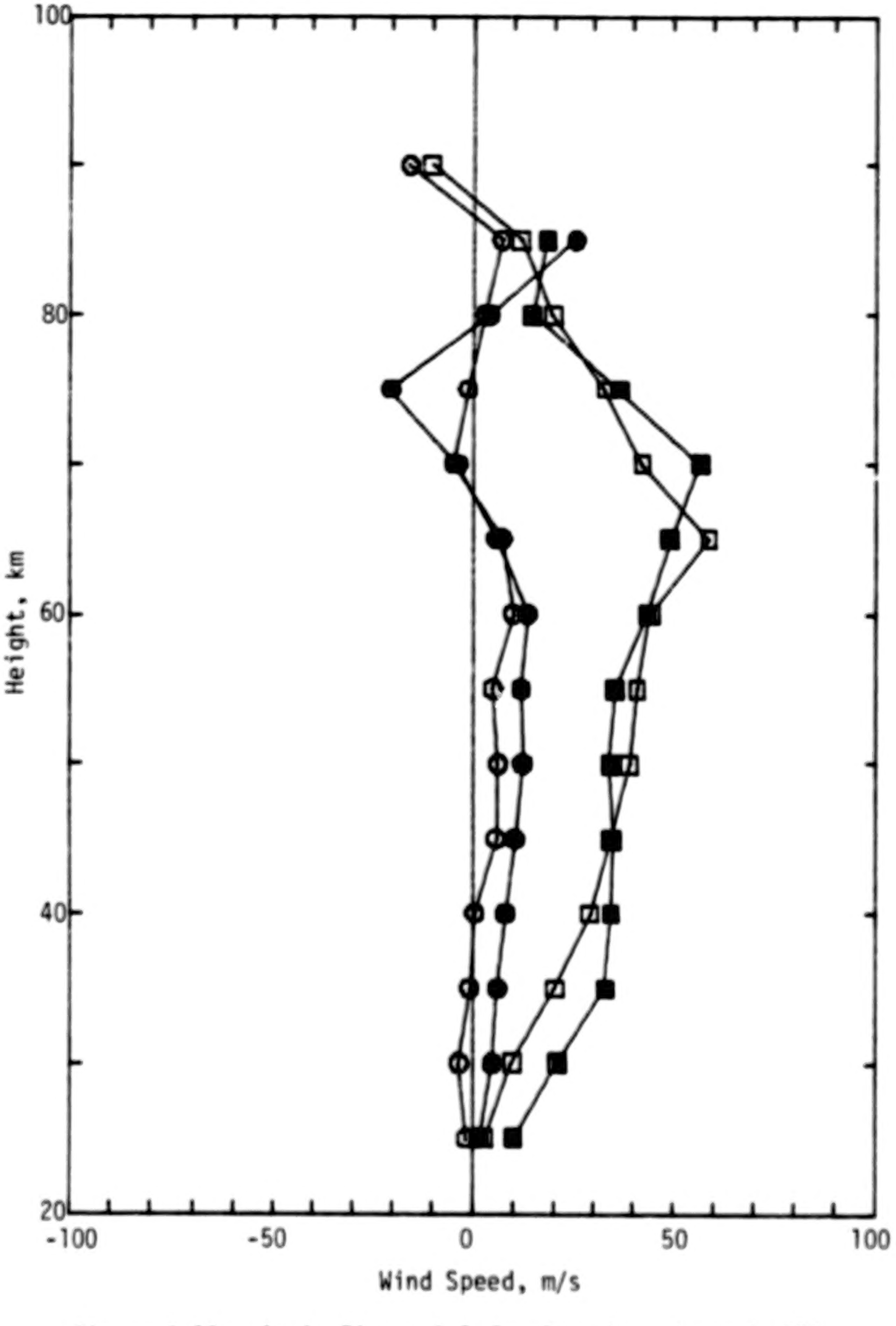


Figure 3.10. As in Figure 3.1 for December, Kennedy SFC.

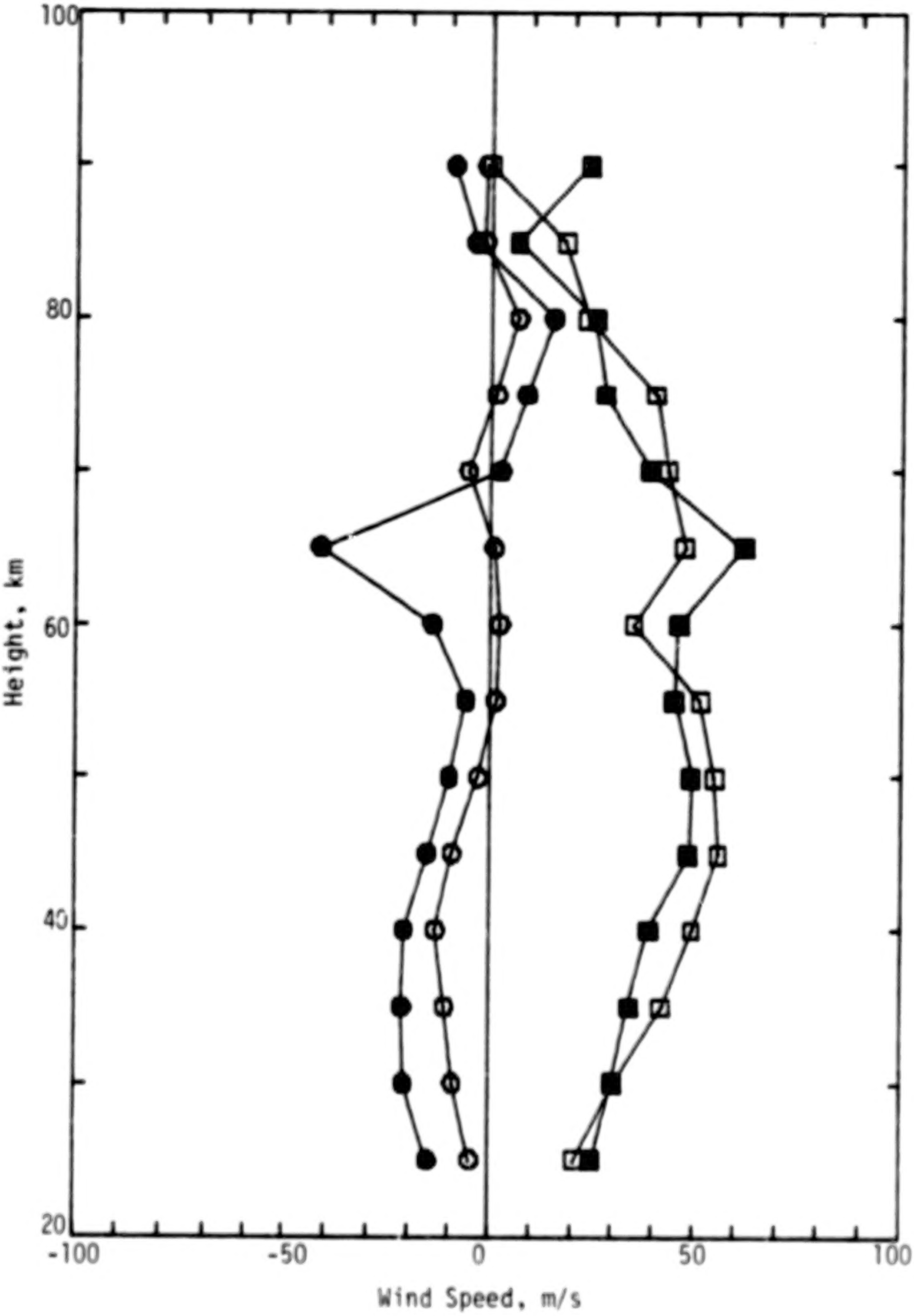


Figure 3.11. As in Figure 3.1 for December, Fort Churchill.

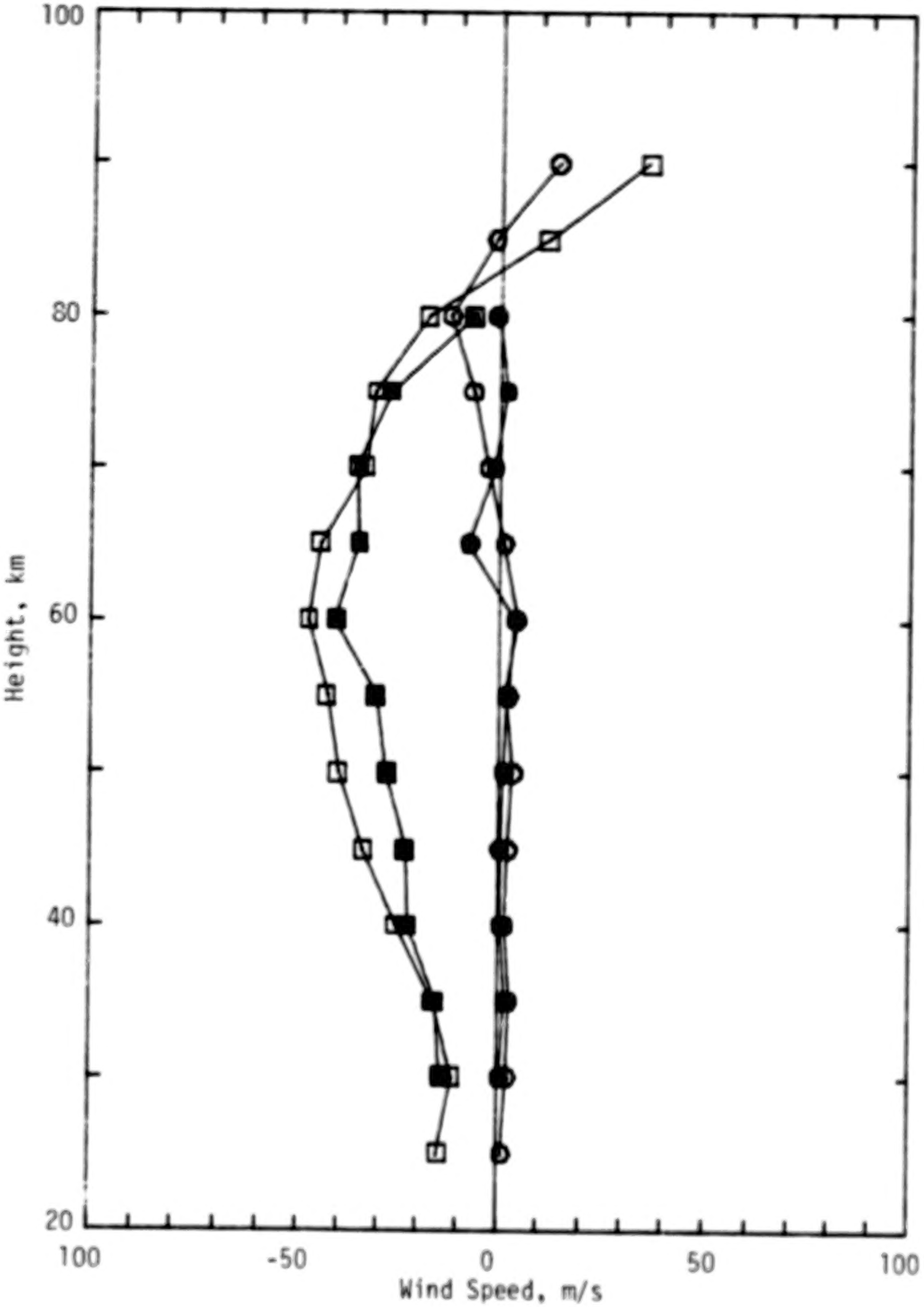


Figure 3.12. As in Figure 3.1 for December, Woomera.

4. USERS MANUAL

The Global Reference Atmospheric Model (GRAM) program is designed to produce atmospheric parameter values either along a linear path (to be called a profile) with automatically stepped constant height, latitude, and longitude increments, or along any set of connected positions (to be called a trajectory) which must be input individually into the program.

There are three general types of input to the GRAM program: (1) A set of three cards, called the initial data, which contain the values of the program options, the initial position, the profile increments, and other information required before the calculations are begun, (2) A data tape (SCIDAT) containing parameter values for the Groves (1971) model, the stationary perturbations (deviations from the Groves model, to produce longitude varying monthly means), and random and quasi-biennial perturbation parameter values, and (3) The data tapes with one data file for each month, containing profiles of monthly mean pressure, density, temperature, and their variances from the surface to 25 km, for the entire globe. If it is desired to compute atmospheric parameters along a trajectory instead of a linear profile, then a fourth type of data - the trajectory times and positions - must be input.

In terms of program function, the major elements of the GRAM program are the main segment (GRAM), the subroutine SCIMOD, which is a driver for all of the atmospheric evaluation subroutines, and SETUP, a subroutine used to read the SCIDAT data tape, and load the necessary starting conditions for execution. Figure 4.1 shows a simplified schematic of the main segment and illustrates the function of the SETUP and SCIMOD subroutines.

Output of the GRAM program consists of monthly mean pressure, density, temperature, wind and wind shear, total (mean plus perturbation) values of

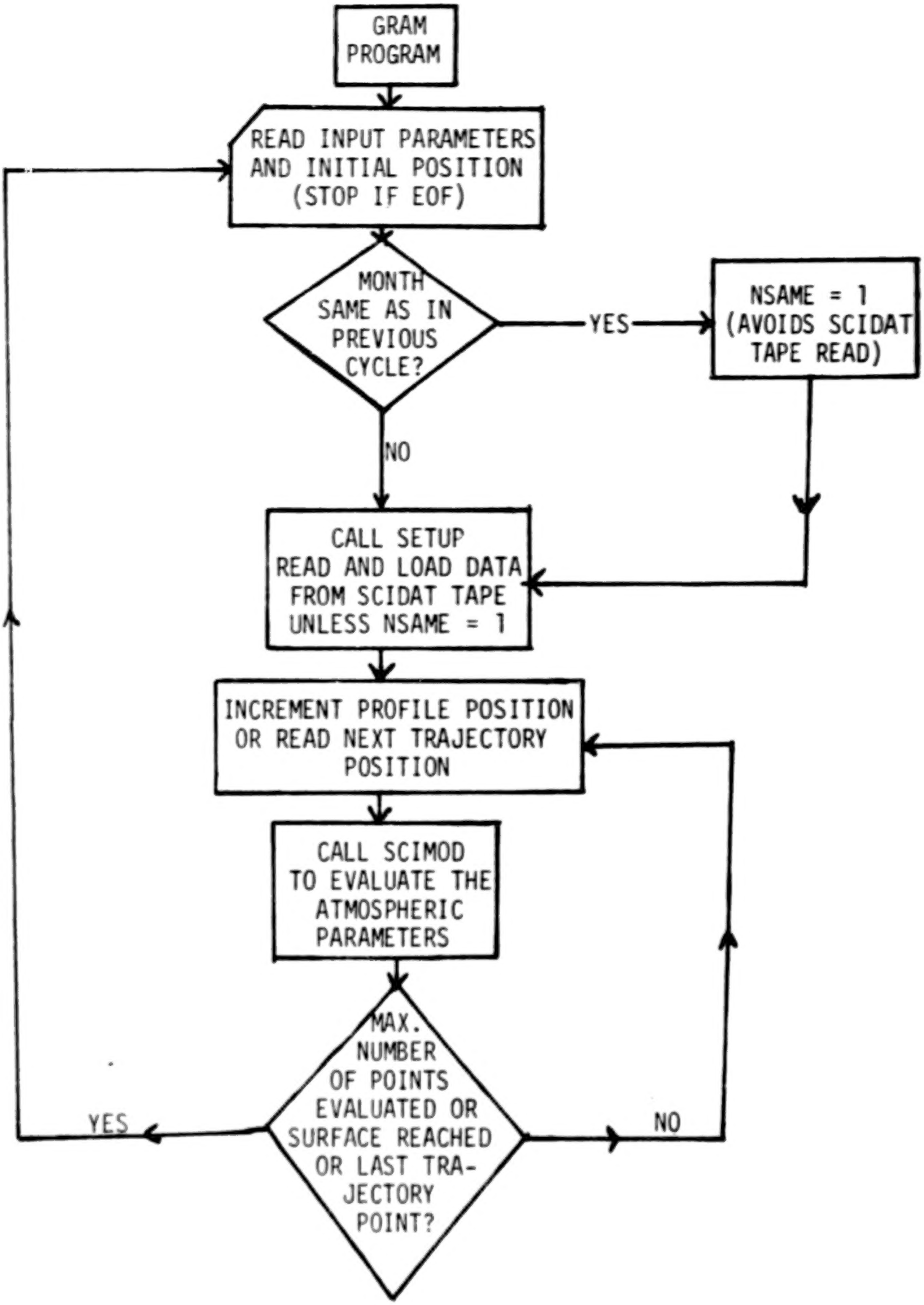

GRAM PROGRAM
READ INPUT PARAMETERS AND INITIAL POSITION (STOP IF EOF)
MONTH SAME AS IN PREVIOUS CYCLE?
YES
NSAME = 1 (AVOIDS SCIDAT TAPE READ)
NO
CALL SETUP READ AND LOAD DATA FROM SCIDAT TAPE UNLESS NSAME = 1
INCREMENT PROFILE POSITION OR READ NEXT TRAJECTORY POSITION
CALL SCIMOD TO EVALUATE THE ATMOSPHERIC PARAMETERS
MAX. NUMBER OF POINTS EVALUATED OR SURFACE REACHED OR LAST TRAJECTORY POINT?
YES
NO

Figure 4.1: Simplified flow chart of the GRAM program.

pressure, density, temperature, winds, perturbation values, and magnitudes.

Complete discussion of the input, output, and program operation characteristics for the GRAM program are given in the following sections of the users manual.

4.1 The 4-D Data Tapes (0-25 km)

The description contained in this section was paraphrased from the 4-D program users manual (Fowler and Willard, 1972). For more information on the 4-D section of GRAM, consult that document and Spiegler and Fowler (1972).

The world-wide meteorological data set developed for the 4-D model by Allied Research Associates is stored on three 7-track, 800 bpi binary tapes labelled WW1A-WW3A. Each tape contains four files of data where one file represents one month; WW1A contains months 1-4, WW2A contains months 5-8, and WW3A contains months 9-12. A 13th month containing the annual reference period has been added as a fourth tape.

Within each file are 3490 records representing the values at individual grid points. These points are grouped into three grids: 288 points on the northern hemisphere equatorial (EQN) grid; 1977 points on the northern hemisphere (National Meteorological Center) grid; and 1225 points on the southern hemisphere (SH) grid. On the NMC grid, the data were computed at NMC points and stored in the order given by the NMC grid table shown in the SCIDAT data tape listing in Appendix B. On the other two grids, the data was given at 5° latitude-longitude intersections westward from the Greenwich Meridian to 5° east. The EQN grid covers the latitudes from 0° to 15° north with points occurring in the following order: 1-4 = Lon. 0, Lat. 0, 5, 10, 15; 5-8 = lon. 5W, Lat. 0, 5, 10, 15; ... 285-288 - Lon. 5° E, Lat. 0, 5, 10, 15. The SH grid contains all data from 5° south to the south pole as follows: 1 = South Pole, 2-18 = Lon. 0, Lat. -5 to -85; 19-35 = Lon. 5^{0} W, Lat. -5 to -85; ... 1209 - 1225 = Lon. 5^{0} E, Lat. -5 to -85. It should be noted that the south pole is given only once, as the first point of the SH data set.

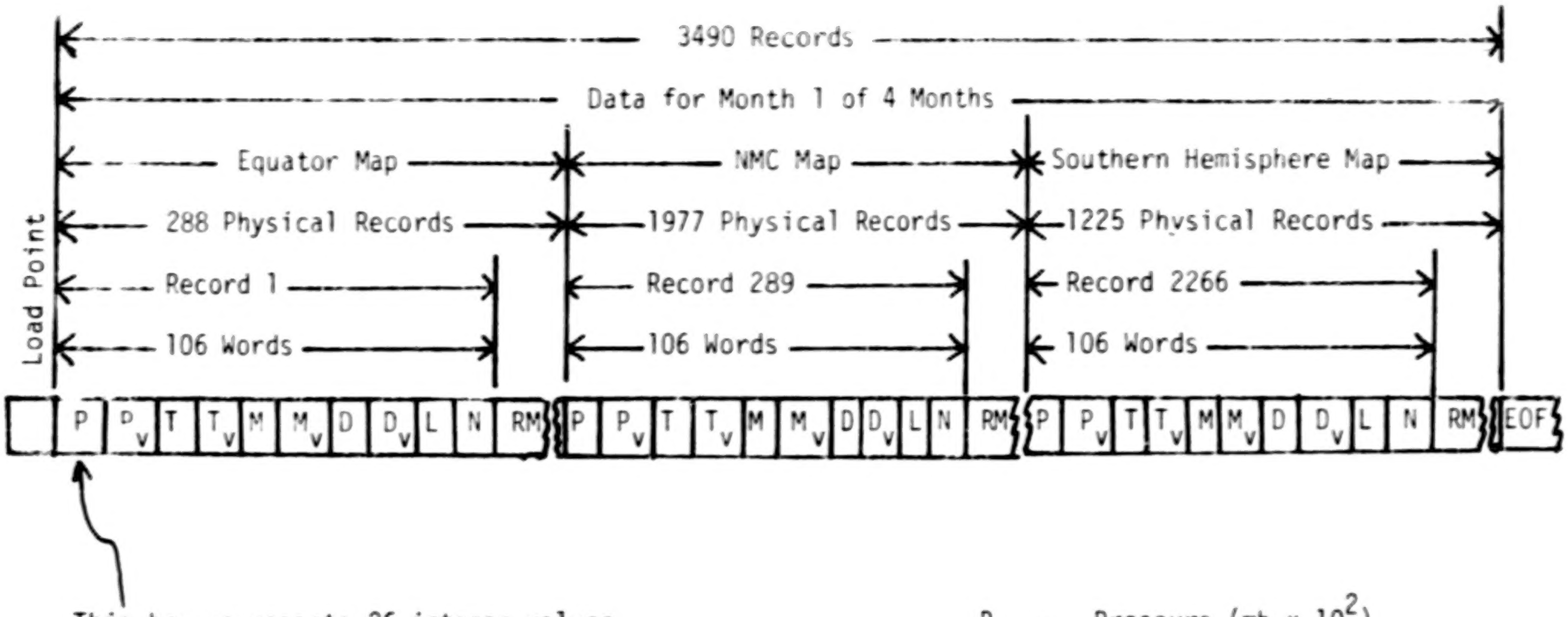
Each record consists of 106 36-bit words where the first 104 words contain the computed data for a point and the last two are identifiers. All data values are multiplied by 100 and converted to integer; they are then packed with two 18-bit values to a word. The data is arranged by level for each parameter; thus, the first 13 words contain the pressure means from the surface to 25 km and the next 13 words contain the pressure variances for the same levels. This pattern continues for the 26 levels of temperature means and variances, moisture means and variances, and density means and variances.

Word 105 contains the latitude and longitude of the point in question. There are integer values that have been multiplied by 10; each occupies 18 bits of the word. The latitude is always positive (since the southern hemisphere is identified by grid), and the longitude is always west.

The last word contains three 12 bit integer values. The left-most group of bits is the homogeneous moisture region in which the point lies, the center group is the point number, and the right-most group of bits is the month. It should be noted that the points are numbered within the grid that contains them, and not by their location on tape. Thus the point numbers run from 1-288, 1-1977, and 1-1225, not from 1-3490. Figure 4.2 shows the tape structure for one month.

4.2 The SCIDAT Data Tape

This section describes in detail the data contained on the SCIDAT data tape. A listing of this tape, and a synopsis of the data contained on



This box represents 26 integer values of pressure in millibars x 10^2. Each value is packed sequentially as an 18 bit byte, starting with the surface and ending with the 25 km value

Variances are the square of the standard deviations.

RM denotes end of record mark.

EOF Denotes end of file mark.

P - Pressure (mb x 10^2)

P_v - Pressure Variance (mb^2 x 10^2)

T - Temperature (^oK x 10^2)

T_v - Temperature Variance ($^oK^2$ x 10^2)

M - Moisture (g/m^3 x 10^2)

M_v - Moisture Variance (g^2/m^6 x 10^2)

D - Density (g/m^3 x 10^2)

D_v - Density Variance (g^2/m^6 x 10^2)

L - Word 105 Containing Latitude and Longitude

N - Word 106 Containing Homogeneous Region Number, MSF Point Number, and Month Number

Figure 4.2: Record Structure on the 4-D Data Tapes

it are given in Appendix B.

NMC Grid Data. This data set gives the 4-D northern hemisphere point number and the dual index for the corresponding NMC location. The NMC grid locations form an octagonal array, centered on the North Pole. The points are at square grid locations on the polar projection used for the NMC grid. A conversion between the latitude and longitude (treated as polar coordinates on the flat NMC grid plane) and the NMC grid indices (treated as Cartesian coordinates on the projection plane) is accomplished by a polar to Cartesian coordinate transformation, via equations programmed into the 4-D model. The NMC grid data on the SCIDAT tape merely establishes the equivalence between the sequential 4-D NMC point number and the two-dimensional x-y NMC grid point location. The NMC grid data constitute the first file on the SCIDAT tape. An end of file marker appears on the tape at the end of the NMC grid data. The NMC grid data file contains 396 FORTRAN readable records with code "N" and 15 integers (A2, 15I7 Format) in each record.

Groves Data. The Groves (1971) data for monthly mean pressure, density, and temperature are tabulated at 10 degree latitude intervals from 0 to 90^0 for each month. The yearly average Groves data is coded as month 13. The southern hemisphere data is the same as the northern hemisphere data displaced by 6 months. Annual mean (month 13) data is the same for both northern and southern hemispheres.

The format of the Groves data is the same as in Groves (1971) original report, except that a prefix code P, D, or T has been added at the front of each record. Each record contains the code, the month, the height in km and the 0, 10, 20, ...,90^0 latitude values of the parameter expressed as a three digit integer, with an exponent common to all of the values in the field appearing at the end of the record. Thus a value of 276 with an exponent at the end of the record of -6, would be the same as 276 x 10^{-6} = 2.76 x 10^{-4}. Pressure data are in units of N/m^2, density values are in kg/m^3, and temperatures are in °K. The Groves data set contains 702 FORTRAN readable records with 13 integer values (13I7) in each record (following the code word P, D, or T, in A2 format).

Stationary Perturbations. The stationary perturbations are latitude-longitude dependent relative perturbations to be applied to the Groves values, considered to be the longitudinal mean value. Data for each of 12 months and for the annual reference period (month 13) are given for the northern hemisphere latitudes. Southern hemisphere data are the same as the northern hemisphere values displaced by 6 months.

Each record contains the code S, the month, the height in km, the west longitude, in degrees, and then 15 values of stationary perturbations in per mill (%/10). The first five of the values are for pressure perturbations at latitudes 10, 30, 50, 70, and 90. The next five values are for density, and the last five values are for temperature. The monthly mean value y_m for parameter y at any latitude and longitude can be computed from the Groves value G_y at the latitude and the stationary perturbation s_y (in per mill) at the latitude and longitude by the relation

$$y_m = G_y (1 + s_y/1000) \qquad (4.1)$$

Note that the stationary perturbation values at 90^0 latitude are always zero. However, there is a place for 90^0 values on the data tape, so that if a systematic departure from Groves values is desired at the poles, a set of stationary perturbation data reflecting this condition could be developed and put on the tape. The stationary perturbations listed on the Mod-3 SCIDAT tape have been revised, as described in Section 2, by the addition of data read from 1964, 1965, and 1972 upper air charts.

The Groves data and stationary perturbation data constitute the second file on the SCIDAT tape. An end of file marker appears at the end of the stationary perturbation data. The stationary perturbation code S data consists of 1248 FORTRAN readable records, with 18 integer values (18I7) (following the code word S A2 format).

The Random Perturbation Data. Random perturbation magnitudes (standard deviations) are latitude dependent only. Each code R record has the code, the month (1-13) and the height in km, followed by 15 values of random perturbation magnitude, five for pressure (in per mill, at latitudes 10, 30, 50, 70, and 90), five for density, and five for temperature. These data give the relative standard deviations σ_p/p, σ_ρ/ρ, and σ_T/T, for use in the random perturbation model.

The code RW data are similar, except that only ten wind values appear in each record (after the code, month, and height): five for eastward wind magnitude (in m/s at latitudes 10, 30, 50, 70, and 90) and five for northward wind magnitude.

The code R and RW total perturbation magnitudes have been revised by the incorporation of new data sources, as described in *Justus and Woodrum*, (1975). The code R data have also been subjected to *Buell* (1970, 1972) adjustment, also described in *Justus and Woodrum* (1975).

The code R and RW data constitute the third file on the SCIDAT tape. An end-of-file mark appears on the tape at the end of the code RW data. The code R data consist of 260 FORTRAN readable records with 17 integer values (17I7) in each record following the code word R (A2). For the code RW data, there are 325 records with the code word RW and 12 integers (A2, 12I7).

Large Scale Fraction Data. From daily difference analysis described in Section 2, the fraction of the total variance (σ^2 from code R and RW data) contained in the large scale perturbations has been determined as a fraction of height and latitude. Separate evaluations by month were also made, but were not found to be significantly different from the annual averages. Therefore the SCIDAT tape contains only the annual average fraction (expressed as per mill) of total variance contained in the large scale. Large scale and small scale magnitudes σ_L and σ_S are computed from the fractional data f_L in per mill (code P for pressure, density, and temperature or code PW for winds), by the relations

$$\sigma_L = \sqrt{f_L/1000}\ \sigma_T \tag{4.2}$$

$$\sigma_S = \sqrt{1 - f_L/1000}\ \sigma_T \tag{4.3}$$

where σ_T is the total perturbation magnitude (code R or code RW data). The code P and code PW data sets each contain 25 FORTRAN readable records, with code word P or PW, followed by 17 integer values (A2, 17I7) on each record.

Density-Velocity Correlations. Daily difference analysis described in Section 2 was also used to evaluate the cross correlations $R_{u\rho}$ and $R_{v\rho}$ for use in the velocity perturbation model (equations (2.38) - (2.41) and (2.44) - (2.50)). Both large scale and small scale values of the density-velocity correlations were evaluated, and are given on the SCIDAT data tape (codes CL and CS) in per mill (i.e. divide by 1000 to get correlations in the range -1 to +1).

The code P large scale fraction data and the code CS and CL density-velocity correlation data constitute the fourth file on the SCIDAT tape. An end-of-file mark appears on the tape at the end of the code CL data. The code CS and CL data consist of 50 FORTRAN readable records, with code word CS or CL, followed by 12 integer values (A2, 12I7) in each record.

The Quasi-Biennial Oscillation (QBO) Data. The QBO data consists of height and latitude dependent amplitudes and phases for quasi-biennial variations in pressure (QP), density (QD), temperature (QT), and eastward and northward wind components (QU and QV, respectively). The amplitude of the QBO thermodynamic parameters are in per mill (%/10). The amplitudes of the QBO wind components are in decimeters per second (0.1 m/s). The phases of all of the QBO parameters are measured in days after January 0, 1966 for the occurrence of the first maximum value. Since the period of the QBO variations is taken to be 870 days, the phases could vary from 0 to 870.

Each QBO data record contains the code, the height in km, the amplitude and phase for 10° latitude, the amplitude and phase for 30° latitude, etc. out to the amplitude and phase for 90° latitude. There are 80 FORTRAN readable records in the QBO data set. Each record contains 11 integer values followed by a code word (QP, QD, QT, QU, or QV).

An end of file mark appears at the end of the code QV data.

The Spherical Harmonic (SP) Data. The spherical harmonic coefficient data consists of values of the 9 spherical harmonic coefficients (equation 2.12) for both northward and eastward wind components. Each record consists of the code (SP), the height (km), the month, and 9 spherical harmonic coefficients (in cm/s). Eastward wind component coefficients are first, followed by northward wind component coefficients.

A final end-of-file mark appears at the end of the SP data. Appendix B gives a brief summary of the data on the SCIDAT tape and a listing of all the values appearing in the tape records.

4.3 The Initial Input Data

The initial input data consists of two free field (no set format with commas after each number) cards containing initial position data, program options, and other information required to begin computation, plus an optional third free field card to give initial random perturbation data if random perturbations are to be computed, plus an optional set of trajectory position data cards (followed by a backup card), if trajectory positions are to be read in rather than a linear profile generated automatically in the program. Appendix C gives a brief summary of the input characteristics, a summary of the data deck setup, and some sample input and output for the program. The following gives a more detailed description of each program input card.

Input Card Number 1. The first input card, read in by the main program segment PROFILE in free field format contains the following information. Designation R indicates real quantities, I denotes integer quantities.

1. Initial Height (R): The initial height in km for the beginning point of the profile or trajectory. This can be any non-negative real number. Atmospheric parameters are never evaluated at the first position, which is used only to establish the initial conditions.

2. Initial Latitude (R): The latitude of the initial position in degrees, with southern latitudes negative. If the initial latitude, or any subsequent latitude is greater than 90° in absolute magnitude, then a transformation

$$\text{lat} = (180^\circ - |\text{lat}|)(\text{lat}/|\text{lat}|) \tag{4.4}$$

$$\text{lon} = \text{lon} + 180^\circ \tag{4.5}$$

is made.

3. Initial West Longitude (R): The west longitude of the initial

position in degrees. East longitude can be put in as negative or converted to 0 - 360^0 west longitude. If negative (east) longitudes are input they are converted to the 0 - 360^0 scale before being used by the program. At any time during the run if a longitude gets outside the 0 - 360^0 range it is put back into that range by adding or subtracting 360^0, as necessary.

4. F10.7 (R): The solar 10.7 cm radio noise flux in units of 10^{-22} watts/m^2 (the normal units for this parameter) at the time for which the atmospheric values are to be computed. This factor is used only in the Jacchia section, so a value of zero can be used on input if the height never goes above 90 km. A value of 230 for both design steady state conditions and for maximum conditions may be used, or consult the Aerospace Environment Division (AED) of Marshall Space Flight Center (MSFC) for monthly predictions.

5. Mean F10.7 (R): The 81 day mean solar 10.7 cm radio flux. This parameter is used in the Jacchia section to compute the nighttime minimum global exospheric temperature (equation (14) in Jacchia, 1970). Use zero if the height does not go above 90 km. A value of 230 may be used for both design steady state or maximum conditions, or consult the AED or MSFC for monthly predictions.

6. AP (R): The geomagnetic index a_p, used to compute a geomagnetic correlation to the exospheric temperature, in equation (22) of Jacchia, (1970). Use zero if the height does not go above 90 km. A design steady state value of 20.3 and a maximum condition value of 400 may be used for a_p, or consult the AED at MSFC for monthly predictions.

7-9. Date (I): The date, for the starting time of the trajectory or profile evaluation in month/day/two digit year form, as three integer input values. The day of the month and the year have no direct effect on the program calculations, except in the case of the quasi-biennial oscillation terms. For the annual reference period, use month 13. The quasi-biennial terms are automatically set to zero if month 13 is used. The month is used to establish which Groves data, stationary perturbation data, and random data (including large scale fractions and velocity-density correlations) to load from the SCIDAT data tape into the working arrays. The program will work more efficiently if multiple trajectories or profiles are evaluated during one run operation and the months are the same. (This avoids repeated look-up of the Groves, stationary perturbation, and random data from the SCIDAT tape.)

10-12. Greenwich Time (I): The Greenwich mean time for the starting position in hours, minutes, and seconds as three integer values. Only the Jacchia section is directly affected by the time of day, so unless the height goes above 90 km, the starting time would serve merely as a reference parameter for the particular run being done. Greenwich time corresponding to a local time of 0900 hours should be used for design steady state Jacchia section conditions, and for maximum conditions the local time should be taken as 1400 hours.

13. Latitude Increment (R): If a linear profile is to be generated automatically this is the latitude increment (in degrees) between successive profile positions. The new latitude would be the old latitude plus the latitude increment. For a profile with decreasing latitude (going southward) the increment must be negative. Use zero if separate trajectory position input is to be read in. If a vertical profile (i.e. changing only height) is to be evaluated, then use zero latitude increment.

14. West Longitude Increment (R): If a linear profile is to be generated automatically this is the west longitude increment (in degrees) between successive profile positions. The new longitude will be the old longitude plus the longitude increment. For a profile progressing eastward use a negative increment. Use zero if separate trajectory position input is to be read in. If a vertical profile is to be evaluated, then use zero increment.

15. Height Increment (R): The height decrease in km between successive positions, for an automatically generated linear profile. The profiles normally are generated downward (descending height). (New height = old height minus the height increment). If an upward generated profile is desired the height increment should be negative. Downward generated profiles will be evaluated until the height is incremented to a negative value or until the maximum number of positions (item 16, 1st card) is exceeded.

16. Maximum Number of Positions (I): The maximum number of profile positions to be generated automatically. This does not include the initial position, for which no atmospheric parameters are evaluated. Use zero if trajectory positions are to be read in.

17. Time Increment (I): The time displacement (seconds) between successive automatically generated profile positions. This would normally be set to zero, but could be used as a counter to be printed out in the time position with the output. For trajectories the time for each position is read in with the position data (see trajectory input section below). The hours, minutes, and seconds parameters (read in as items 10-12, 1st card) are updated according to the new time generated by the time increment. However, only the elapsed time in seconds is printed out on the present output.

18. Trajectory Option (I): This option tells the program whether a trajectory or a linear profile is to be evaluated. A value of 0 means a linear profile is to be generated automatically from the parameters read on the first card. A value greater than zero means that trajectory position data must be read in to determine the positions at which atmospheric parameters are to be evaluated. The unit from which the trajectory data are to be read is specified by the (non-zero) trajectory option. Thus, if trajectory data are to be read in from cards, use a trajectory option of 5 (the card input unit).

19. Output Option (I): This option tells the program whether or not to produce non-print output of the atmospheric parameters (see the output description section). Non-print (i.e. disk or cards) output is convenient to use as input to plotter programs. A value of 0 means no non-print output. A value greater than 0 means to output the data on the unit number equal to the output option value.

20. Minimum Geostrophic Latitude (R): Below this latitude (in absolute magnitude) the second order geostrophic relations are used. Above this latitude, or above 90 km, only the usual geostrophic relations are used.

With normal numbers of decimal places and no unnecessary blank spaces, the above 20 items should fit onto one card. However, if they occupy more than the 80 columns allowed on one card, they may be spread out onto two cards if the following rules of free field input are observed on the first of the two cards: (1) Do not put a comma after the last number appearing on the first card. (2) If the last number on the first card is an integer, it should be right justified to column 80. For input on other computers, consult your operations manual for characteristics of free field input.

Input Card Number 2. The second input card is read in by the subroutine SETUP and contains various unit numbers to be used and options controlling the random and quasi-biennial calculations. The unit numbers are the parameters used in read statements in the FORTRAN program to control which file is being read from. The unit numbers are required in the input in order to give maximum flexibility in choice of I/O devices for the program. All input items on card number 2 are integers.

1. Groves Input Unit: This is the unit number of the SCIDAT tape file. If the SCIDAT tape has been assigned by the UNIVAC control statements -

```
@ ASG, T     SCIDAT,   T,   U1961 N
@ USE      3, SCIDAT
```

where U1961 is the reel number for tape SCIDAT, then the Groves input unit number should be 3 on this input card. The Groves and stationary perturbation data must be read from the SCIDAT tape. Later options on this card allow the NMC grid data, the random perturbation data, and the quasi-biennial data each to be read from other files.

2. Random Input Unit: This is the unit number for the random perturbation standard deviations (and the large scale fraction data and density-velocity correlations). If this unit number is the same as the Groves input unit number, then all of the random perturbation data are read from the SCIDAT data tape. Otherwise all of the random perturbation data are read from the file for whatever the unit number is set to. For card input, the unit number should be set to 5. The SCIDAT tape is read with NTRAN, but if alternate random data are read in from a different file, the file

must be FORTRAN readable with format

1X, A1, I2, I4, 3(1X, 5I4)

for the random pressure, density, and temperature data (see Appendix B and Section 4.3 for which values must go in each record). For the random wind data the FORTRAN readable format for the alternate data is

1X, A2, I2, I4, 2(1X, 5I4)

If the random data input unit is different from the Groves input unit, then the code P and PW large scale fraction data and code CS and CL density-velocity correlation data must follow (after an end-of-file) the code RW data on the random input unit. The FORTRAN readable format for the large scale fraction (code P) data is

1X, A1, I2, I4, 3(1X, 5I4)

The format for the code PW data is

1X, A2, I2, I4, 2(1X, 5I4)

The format for the CS and CL data is

1X, A2, I2, I4, 2(1X, 5I5)

See Appendix B and Section 4.3 for description of the values which must go in each of these records.

All of the random perturbation data, random pressure, density, and temperature data, random wind data, large scale fraction data, and density-velocity correlation data must be read in from the same file, either all from SCIDAT, or all from the alternate FORTRAN readable file.

3. QBO Input Unit: If the QBO data parameters are to be read in from the SCIDAT data tape, this unit number is set the same as the Groves input unit. If alternate QBO parameters are to be read in the QBO unit number can be any FORTRAN readable file. Use Unit 5 for card input. The

format for all of the alternate QBO input is

1X, A2, I3, 5(I4, I5)

(See Appendix B and Section 4.3 for which data values must go into each record). All of the QBO pressure, density, temperature, and wind data must be read from the same file, either all from SCIDAT or all from the alternate QBO input file.

4. 4-D Input Unit: This is the unit number for the 4-D data tape. Any available unit number can be used. If the 4-D tape WW1A, containing the January data, has been assigned by the control statements

```
@ ASG,   T   WW1A,   T,  U 2400 N
@ USE   4,   WW1A
```

then the 4-D input unit number is 4.

5. Random Option: This option tells the program whether or not to compute random perturbations. If the value is 1 random perturbations are computed. If the value is 2 then random perturbations are not computed. If any values other than 1 or 2 are input the run is terminated with a message "ERRØR IN SETUP INPUT" and a dump of the parameters most recently read in.

6. QBO Option: This option tells the program whether or not to compute QBO perturbations. If the value is 1 QBO perturbations are computed. For 2 no QBO perturbations are computed, and for any other values the "ERRØR IN SETUP INPUT" and dump of most recent parameters read in is given.

7. First Random Number: This number is required as a starting parameter for the random number generating subroutine RAND. Any odd positive integer can be used. Use a value of 1 for a standard design appli-

cation run. Provided all other input is the same, a given value for the starting random number will always produce the same random perturbation output. Therefore, to get a set of different perturbations along a given single trajectory, a set of different starting random numbers should be used. Note, however, that if any other parameters are changed (different spacing along the trajectory, different starting position, etc.) then the same starting random number will produce a different set of random perturbations.

8. NMC Read Option: This option tells the program whether to read the NMC grid data from the SCIDAT data tape (value 0 for the option) or from an input card file (any non-zero value for the option).

9. 4-D Scratch Unit: In order to save array space the 4-D profiles required to interpolate to the 5° x 5° grid locations are read from the tapes to this scratch file rather than being put into arrays. The unit number for this scratch file can be any available unit. Normally the file is a temporary drum file, and, if so, does not (on the UNIVAC) have to be assigned (@ ASG) before execution of the program.

10. NMC Grid Point Scratch Unit: Also in order to save computer storage, the NMC grid point array read in from the SCIDAT tape (or from cards) is stored in a temporary scratch file (usually on drum). If the drum scratch file is used, it does not have to be assigned (on the UNIVAC) before execution of the program.

Input Card Number 3. This card is read by the SETUP subroutine and contains starting values for the random perturbation parameters at the initial position. If random perturbations are not to be computed (Random Option = 2), then this card should not be put in. All values of this free field format card are real. For a normal design application the values on this card should all be zero, unless the run is to be a continuation of a previously run trajectory or profile segment, in which case the output random parameters of the last output position are input, and the last output position becomes the initial position of the new run.

1-6. Initial PL, PS, DL, DS, TL, TS: These are initial values of random relative pressure ($p'/\bar{p}$), density ($\rho'/\bar{\rho}$), and temperature ($T'/\bar{T}$) in percent for the large scale (L) and small scale (S) components. These are starting values for the initial position. Use zero for standard design applications.

7-10. Initial UL, US, VL, VS: Initial values of the random eastward (U) and northward (V) random wind components in m/s for the large scale (L) and small scale (S) components. Use zeros for standard design applications.

Trajectory Input. The free field trajectory position input and backup record are put in only if a trajectory is to be evaluated, rather than a linear profile, generated automatically in the program from information on the first input card. There is no limit to the number of trajectory position records which can be put in. The program continues evaluating the atmospheric parameters and looping back to read a new trajectory position until a position below the surface is reached, or until the trajectory backup record is reached. Each free field trajectory record has the time (integer seconds), the height (kilometers), the latitude (degrees, southern latitude negative), and the west longitude (degrees, 0-360° or east longitudes negative). Any east longitudes read in as negative values are converted to the 0-360° system before being used by the program. The trajectory backup record has the same free field form as a regular trajectory record, except any negative value for height is used. The negative height terminates the loop which evaluates atmospheric parameters and reads a new trajectory record. If a trajectory height goes negative, then any remaining trajectory input cards are read and ignored. The trajectory input can either be input from cards (trajectory option = 5) or form any other unit (with trajectory option = unit number). The trajectory option is item 18 on card #1.

4.4 Output of the Program

The first few lines of print output are primarily a listing of the input parameters. Following a heading which describes each output value for the trajectory or profile evaluations, the position, time monthly mean and total pressure, density, temperature, and winds are listed for each position. The thermal wind shear for the monthly mean winds, the percent deviation from the standard atmosphere (p, ρ, and t), the mean vertical wind and the perturbation data are also given for each

position. The perturbation data consist of the stationary perturbations, the quasi-biennial values at the position and time, the quasi-biennial magnitudes, the random perturbation values, and the random perturbation standard deviations. Optional non-print (e.g. disk or punch) output for values at each position is also available to be used for input to plotter programs, or for other purposes.

Heading Information. Primarily the heading information contains a listing of the input data values. However, there are some changes from the values input. If an east longitude is put in as a negative value, -180° < lat < 0°, then it is converted to a west longitude in the 0-360 range before the heading is listed. The program evaluates the initial random pressure, density, temperature and wind standard deviations and the initial density velocity correlation from data on the SCIDAT data tape, and lists the computed values on the heading. The Julian date is computed by the program from the input date and is also listed with the heading information. The Julian date is required by the Jacchia and QBO sections of the program. If month 13 (annual reference period) is input, then the Julian date is set to zero. (The Jacchia section takes the exospheric temperature to be 1000° K and the QBO section is bypassed if month 13 is input).

Position and Time Output. Positions and times as generated by the automatic linear profile features or as input by the trajectory input cards are listed on the output. The time is given in seconds. Within the program, the input time in hours, minutes, and seconds are updated in that form also. However, only a continuously increasing time in seconds is printed out. If time in hours, minutes, and seconds were desired, these variables could easily be printed out by adding them to the output list. All output west longitudes are converted to the 0-360 range before being printed out. If a latitude greater than 90° in absolute magnitude is generated (or input) then a transformation

$$\text{lat} = (180^\circ - |\text{lat}|)(\text{lat}/|\text{lat}|) \qquad (4.6)$$

$$\text{lon} = \text{lon} + 180^\circ \qquad (4.7)$$

is made.

Monthly Mean Data. The monthly mean values of pressure, density, and temperatures, consist of either: (1) values from the 4-D data tapes if the height is below 25 km, (2) the sum of Groves plus stationary perturbation values if the height is between 30 and 90 km, (3) an interpolation between 4-D at 25 km and Groves plus stationary perturbations at 30 km if the height is between 25 and 30 km, (4) Jacchia model values if the height is above 115 km, or (5) faired values between Groves and Jacchia if the height is between 90 and 115 km.

The percent deviations from the U.S. 1962 Standard Atmosphere are evaluated by using standard atmosphere values computed by the subroutine STDATM. The percent deviations are evaluated by the relations $100(T - T_s)/T_s$, $100(\rho - \rho_s)/\rho_s$, and $100(p - p_s)/p_s$, where the subscript s refers to the standard atmosphere values. This subroutine accurately reproduces the tabulated U.S. Standard Atmosphere 1962 values to within an accuracy of better than 0.2% above 90 km. The STDATM values are based on a model of parabolic segments for the height variation of the molecular weight above 90 km. The subroutine reproduces the tabular values even more accurately in the height region below 90 km, where the molecular weight is constant. Since the U.S. 1962 Standard Atmosphere is not defined above 700 km, the percent deviations printed out for heights above 700 km are zero.

The thermal wind shear values are values of $\partial u/\partial z$ and $\partial v/\partial z$ for the monthly mean geostrophic wind (see Section 2). The wind values, computed from the usual geostrophic wind equation or the second order geostrophic relation if the latitude is less than the input value of minimum geostrophic latitude, are determined by horizontal gradients of the monthly mean pressure. The thermal wind shear components, computed by the thermal wind equations, are determined by the horizontal gradients of the monthly mean temperature. Thus, a comparison of numerically differentiated geostrophic mean winds and the thermal wind shear serve as a check of the mean pressure and temperature fields. The mean vertical wind is evaluated, as described in Section 2, by combinations of horizontal and vertical temperature gradients and the geostrophic winds.

The Total (Mean Plus Perturbation) Data. The parameter values listed under the heading of "Mean Plus Perturbations" are the monthly mean values, as defined above, plus the random perturbations, plus (if the height is between 10 and 90 km) the quasi-biennial perturbations. These mean-plus-perturbation values represent values which would be typical "instantaneous" values of the pressure, density, temperature or winds. The percent deviations from the U.S. Standard atmosphere are computed in the same way as for the percent deviations of the monthly mean values from the standard atmosphere.

Perturbation Values. The data under the "Perturbation Values" heading are the various perturbation values, magnitudes, and amplitudes. The stationary perturbations (denoted SP on the printout) are defined only if the height is between 30 and 90 km. The monthly mean y_m of parameter y should be the Groves value G_y, evaluated from the SCIDAT data tape, modified by the given stationary perturbation value s_y, in percent, by the relation

$$y_m = G_y (1 + s_y/100) \tag{4.8}$$

The data labeled "QBO" are the values of the QBO oscillation at the output time and position. The data labeled "MAG" gives the magnitude of the QBO oscillations at the output position and time. The QBO perturbation values should always be less than or equal to the magnitude values in absolute value. The data labeled "RANL", "RANS","RANT" are the large scale, small scale and total random perturbations evaluated at the output time and place. The data labeled "SIGL", "SIGS", and "SIGT" are the standard deviations of the large scale, small scale, and total random components at the output time and positions. According to the Gaussian distribution, on which the random perturbations are based, the perturbation values should be within the range

$\pm\ \sigma$ 68% of the time and outside the range $\pm\ \sigma$ 32% of the time. Similarly, the perturbation values should be within the range $\pm\ 2\sigma$ 95% of the time, and outside the range $\pm\ 2\sigma$ 5% of the time. The evaluation of the QBO and random perturbation output can be suppressed by the QBO and random options, if desired.

Non-Print Output. The non-print output is available as an option, controlled by the input value of the output option parameter. If non-print output is desired, it comes out in the form of records with format F5.1, F6.2, F7.2, 2F5.1, 3F5.0, 5F5.1, 2E10.3, I5, I3 containing the following information: (1) the height in km, (2) the latitude in degrees, (3) the west longitude in degrees 0-360, (4-5) the percentage deviation of the mean monthly values of pressure and density from the 1962 U.S. Standard Atmosphere, (6) the monthly mean temperature, (7-8) the eastward and northward components of the monthly mean (geostrophic) wind, (9-13) the magnitudes of the total random perturbations in pressure, density, temperature (per cent, and eastward and northward wind (m/s), (14-15) the monthly mean pressure (N/m^2) and density (kg/m^3), (16) the time, in seconds, and (17) the month (with 13 indicating annual mean).

4.5 Program Diagnostics. There are several possible reasons which can cause the printing of diagnostic messages and termination of the run during the SETUP phase. If, during the setup procedure, the NMC grid point number data table does not contain the required 1977 values, a message Diagnostic 1: "N RECØRDS WRITTEN BY SETNMC IN SCRATCH FILE M" is printed, and EXECUTION IS TERMINATED. This situation should only arise if the NMC grid point table is being read from cards, rather than the SCIDAT data tape. If during the reading of the SCIDAT data tape, any record is read which does not have the expected code character or characters (N, P, D, T, S, R, RW, P, PW, CS, CL, QP, QD, QT, QU, QV, or SP; see Appendix B), then the message results

Diagnostic 2: "ERROR IN SETUP INPUT" followed by a listing of the latest data values read in. This message is also produced if the random option and the quasi-biennial option do not have a value of either 1 or 2. Any condition which results in this error message terminates the execution.

There are also general conditions which could result in diagnostic messages in the 4-D section: If during the reading of the 4-D data tape on the first access of the region below 30 km, a parity error is encountered, a message

Diagnostic 3: "INPUT UNIT NØ. M IN ERRØR (-3) FØR RECØRD NØ N" is printed - execution continues. Such an error will only be of consequence if the particular record read is required for interpolation. If an end of file is read, a message is written

Diagnostic 4: "***** UNIT NØ. JT IN ERRØR IRC RECØRDS READ
IREAD(IRN, 3) + XXXX MP = XX MØNTH = XX IP = XXXX IPT(I, J) = XXXX IRN = XX
M STATUS L"

Where

JT = Unit on which 4-D data tape is mounted

IRC = Total number of records read thus far from 4-D tape

IREAD(IRN, 3) = Sequential point number selected by SELEC4

MP = Month word in last record read

MØNTH = Run month

IP = Point number word in last record read

IPT(I, J) = Point number required for profile J to be interpolated to Ith requested profile

IRN = Sequential point number required

M = Unit status (READ)

L = NTRAN status (-2 for end of file, -3 for parity, etc.)

and EXECUTION IS TERMINATED

If IRC > IREAD(IRN, 3), the diagnostic message 4 is written - L should be 106, and IRC and IREAD values should indicate this condition. EXECUTI0N IS TERMINATED.

If MP ≠ M0NTH, or IP ≠ IP(I, J) the diagnostic message 4 is printed, again with L = 106, and MP/MONTH or IP/IP(I, J) indicating error. EXECUTI0N IS TERMINATED.

The writing of scratch file SCRCH1 with data for subsequent unpacking and interpolation is also checked. If there is a write error, the diagnostic 4 is printed, with JT the scratch file unit number, M as WRITE and L as -3 or -4. EXECUTI0N IS TERMINATED.

These diagnostics can arise if a bad or wrong 4-D data tape is being accessed, or if there is a malfunction of the tape drive. In some cases a tape will, for example, indicate parity errors when being read from one tape drive, but not another.

If, during the course of evaluation of position in the 4-D height range, it is found that the position is outside the previously established 4-D grid, then a new grid is generated by calling GEN4D. If this occurs again, the message results

Diagnostic 5: "UNABLE TO GENERATE 4-D GRID" and EXECUTI0N IS TERMINATED.

The wind diagnostic symbol (asterisk), has also been added to the program. Presence of the asterisk between the E-W and N-S wind components on the print output indicates a diagnostic condition yielding questionnable wind values. The conditions which can produce this is a 4-D data consistency check violation (i.e., unrealistic scale heights or unrealistic horizontal pressure gradients) within the 4 x 4 grid of 4-D data profiles.

Diagnostic 6: "PREMATURE END-OF-FILE FOUND ON UNIT M"

"CALLED FROM SUBROUTINE XXXXXX"

And end-of-file mark was encountered before it was expected by one of the following subroutines while it was loading the associated data.

XXXXXX	DATA
GETNMC	NMC GRID DATA
RTRAN	STATIONARY OR RANDOM PERTURBATION DATA
RTRAN1	GROVES DATA
RTRAN2	QBO DATA

UNIT m refers to the input unit number. This error should never occur while using the SCIDAT data type as the data source.

5. PROGRAMMERS MANUAL

5.1: Description of Subroutines

The following is a brief description of each of the PROFILE program subroutines, in alphabetical order:

ADJUST:	Adjusts the 4-D profiles of pressure, density, and temperature variance (read from the 4-D tapes) to satisfy the Buell constraints imposed by the perfect gas law and hydrostatic equation
CHECK:	A consistency check routine for the 4-D 16 profile grid data produced by GEN4D. CHECK is called for each height to be evaluated, and tests for reasonable values of scale height immediately above and below that height. It also tests for reasonable horizontal pressure gradients. Failure of either test produces the diagnostic asterisk between the output values of wind components.
CORLAT:	Evaluates the horizontal and vertical scales for large and small scale density, temperature, and wind components, computes the autocorrelations and cross correlations for the two scale perturbation model, and evaluates new perturbation values having appropriate correlations with the perturbations at the previous position.
DIAGEQ:	A matrix diagonalizing procedure used by the ADJUST subroutine.
FAIR:	Fairs between the Groves and Jacchia values in the 90 to 115 km height range.
GEN4D:	Generates the polar (|latitude| > 75°) or non-polar (16 5° x 5° points) grid of pressure, density, temperature and variance profiles. See Figure 5.1 for a flow chart of this subroutine.
GETNMC:	Reads the NMC grid point values from the SCIDAT data tape or from cards and loads them onto a scratch file. This subroutine is essentially unchanged from the subroutine of the same name in the original 4-D program.
GRAM:	The main segment of the Global Reference Atmospheric Model program. The main segment serves as a driver for the SETUP and SCIMOD subroutines.

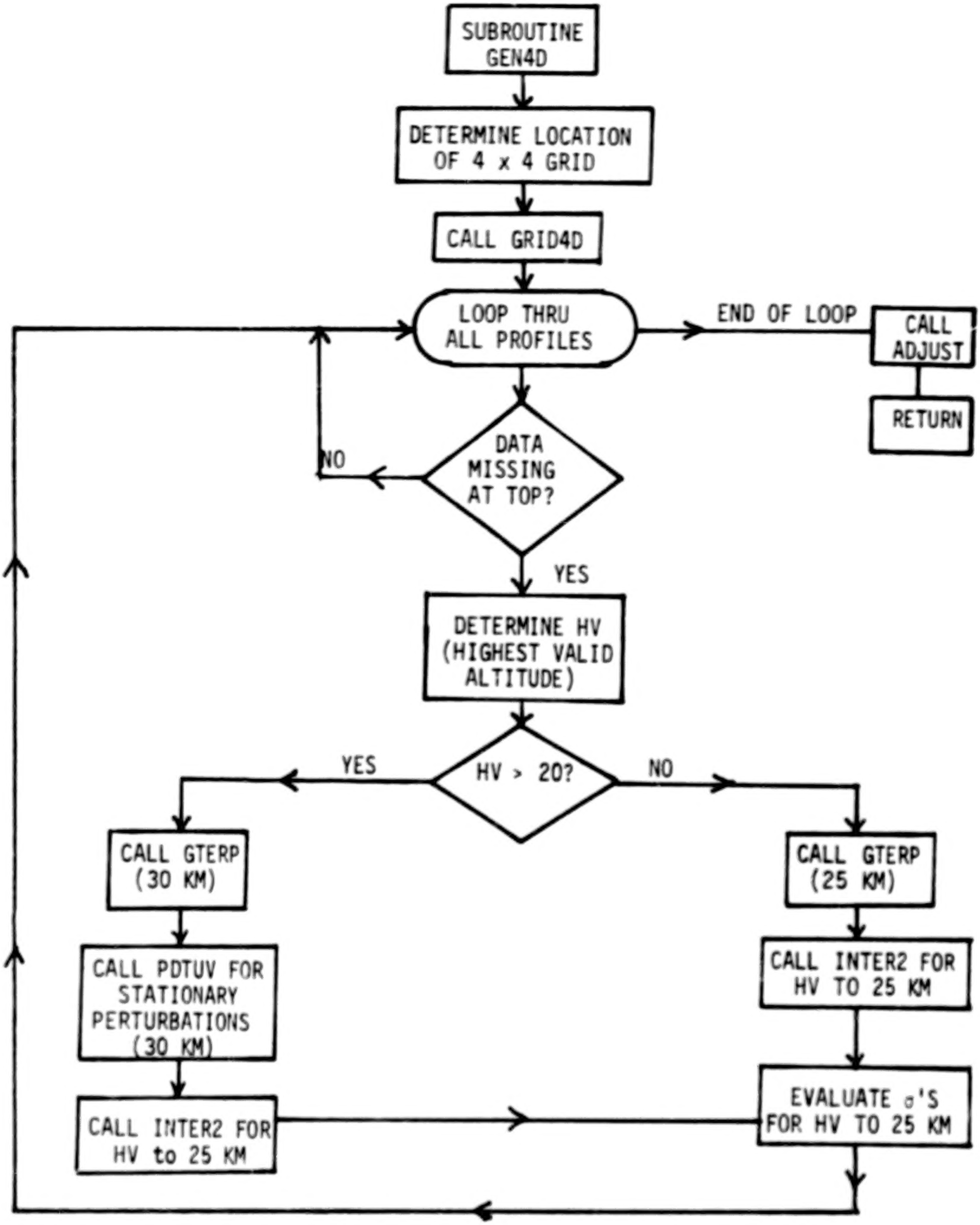

SUBROUTINE GEN4D
DETERMINE LOCATION OF 4 x 4 GRID
CALL GRID4D
LOOP THRU ALL PROFILES
END OF LOOP
CALL ADJUST
RETURN
DATA MISSING AT TOP?
NO
YES
DETERMINE HV (HIGHEST VALID ALTITUDE)
HV > 20?
YES
NO
CALL GTERP (30 KM)
CALL PDTUV FOR STATIONARY PERTURBATIONS (30 KM)
CALL INTER2 FOR HV to 25 KM
CALL GTERP (25 KM)
CALL INTER2 FOR HV TO 25 KM
EVALUATE σ'S FOR HV TO 25 KM

Figure 5.1: Simplified flow chart of the GEN4D subroutine.

GRID4D: After array of 4-D grid lat-lons has been evaluated, this subroutine looks up the data from the 4-D data tapes and interpolates to determine profiles of pressure density, temperature, and variance at the 4-D grid locations. Profiles to be interpolated to 4-D grid locations are loaded onto a scratch file from the tapes before the interpolation is done.

GROUP A subroutine, called by CHECK, which groups the 16 4-D pressure data at the given height into one or more groups which have consistent and reasonable horizontal pressure gradients within each group. If the subsequent geostrophic wind calculations in WIND use horizontal pressure gradients evaluated from differences across inconsistent groups of 4-D data, the diagnostic asterisk is printed between the output values of wind components.

GTERP: Uses linear latitude interpolation and linear temperature and linear logarithm of density interpolation on height to evaluate Groves data to a given latitude and height. See Section 5 of Justus et al (1974a).

INTERW: Two variable linear interpolation between known value U1 and V1 at Z1 and U2 and V2 at Z2 to determine U and V at Z, where Z is between Z1 and Z2.

INTERZ: Three variable interpolation, linear on temperature, and gas constant ($R = p/\rho T$), and linear on the logarithm of pressure, with pressure computed from perfect gas law and interpolated temperature and density, and gas constant.

INTER2: Three variable interpolation, linear on all three variables.

INTER4: Interpolates between the pressure, density, and temperature profiles at the 4-D grid locations. This subroutine calls subroutine INTLL to do the latitude interpolation.

INTLL: One variable interpolation between values in an array of latitude and longitude locations by equation (5.6) of Justus et al (1974a).

INTRP4:	The subroutine for the latitude-longitude interpolation of values from the 4-D data tapes into the 4-D grid array. This is a modification of the INTERP subroutine of the original 4-D program.
INTRUV:	Evaluates the standard deviations of the random wind components at given height and latitude by calling INTERW subroutine.
JAC:	Calculates the molecular weight, density, and temperature for the Jacchia model.
JACCH:	Main subroutine of the Jacchia section, serves as a driver for JAC and other Jacchia section subroutines. JACCHIA also evaluates the seasonal and latitudinal variations in the lower thermosphere.
NORMAL:	Computes two independent random numbers selected from a Gaussian distribution with mean zero and unit standard deviation.
PDTUV:	Interpolates the stationary perturbations on latitude and longitude at a given height. This subroutine is similar to INTLL.
PERTRB:	Evaluates the pressure, density, temperature and wind component random perturbations by the correlated random perturbation model discussed in Section 8 of the technical description section of the report.
PHASE:	A linear height-latitude interpolation routine for the quasi-biennial phase. The interpolation properly accounts for the phase discontinuity between 0 and 870 days (the quasi-biennial period).
QBOGEN:	Computes the QBO perturbation values and their amplitudes and phases. The amplitudes and phases of the QBO pressure, density, temperature, and wind perturbations are interpolated from the amplitude and phase data from the SCIDAT data tape, by calling the INTERZ and INTERW subroutines.
RAND:	Produces a random number selected from a uniform distribution between 0 and 1. This is required as input to the subroutine NORMAL.
RIG:	Computes the acceleration of gravity and the radius from the center of the Earth for a position at a given latitude and height.
RTERP:	Computes the standard deviations of the random pressure, density, and temperature perturbations by calling subroutine INTERZ.

RTRAN: This subroutine contains several NTRAN read sections with multiple entry points coming from subroutine SETUP. The NTRAN read statements are for reading the SCIDAT data tape.

SCIMOD: The heart of the GRAM program. This subroutine branches on height to evaluate the atmospheric parameters by the Jacchia, the modified Groves, or the 4-D methods. The QBO and random perturbations are also evaluated and the output is printed (and optionally also punched) by the SCIMOD subroutine. See Figure 5.2 for a flow chart of the SCIMOD subroutine and Figure 4.1, for a flow chart showing how SCIMOD fits into the overall GRAM program.

SELEC4: Selects the 4-D data needed for interpolation. This subroutine is a modification of the INPUT subroutine of the original 4-D program.

SETUP: This subroutine reads in the NMC grid points with the GETNMC subroutine and reads and loads the data from the required month on the SCIDAT data tapes into arrays. See Figure 5.3 for a flow chart of the SETUP subroutine, and Figure 4.1 for a flow chart showing how SETUP fits into the overall GRAM program.

SORT4: Sorts the 4-D locations for sequential tape reading from the 4-D data tapes. This subroutine is a modification of the SORT subroutine from the original 4-D program.

SPHERE: Called by WIND, this subroutine evaluates the wind components by the spherical harmonic model.

STDATM: Evaluates the 1962 U.S. Standard Atmosphere values of pressure, density, and temperature, at any given height up to 700 km.

TINF: This subroutine computes the exospheric temperature for the Jacchia model.

TME: This subroutine calculates the variables necessary for input into the subroutine TINF in the Jacchia model.

WIND: This subroutine evaluates the geostrophic winds from input values of horizontal pressure gradient if the height is less than 25 km or more than 90 km. If the latitude is below the minimum geostrophic latitude, it evaluates geostrophic wind at minimum geostrophic north latitude and at minimum geostrophic south latitude and then interpolates in between. If the height is between 25 and 90 km, the spherical harmonic wind model is used. Between 20 and 25 km and between 90 and 95 km, a smooth fairing between geostrophic and spherical harmonic wind is used.

The UNIVAC tape reading library routine NTRAN is not available on all computers. However, a similar function (reading 36 bit binary integer arrays in tape records) can be performed easily by alternate program techniques. For example, on Georgia Tech's CDC Cyber 74 system, this function is done by BUFFER IN statements. These routines are used to read the SCIDAT and 4-D data tapes. Also the FLD function, a UNIVAC library routine used to divide the 36 bit 4-D tape words onto 2 18 bit integers, must also be programmed by alternate methods on non-UNIVAC machines. On Georgia Tech's CDC machine, this is done by specially written subroutines (WRDCHG, RFLD, and FLD) which utilize the SHIFT and MASK bit manipulating CDC library routines.

If the GRAM program is mapped without segmenting the program, it requires approximately 80 K decimal words core storage on Georgia Tech's CYBER. In order to take up less core storage (e.g., be accommodated into smaller core partitions), the program can be mapped in segmented form. An efficient segment of the program can be accomplished by subdividing the program into a primary segment, a setup segment, a Jacchia segment, and a 4-D segment. The primary segment should contain CORLAT, GRAM, GTERP, INTERW, INTERZ, INTER2, INTRUV, NORMAL, PDTUV, PERTRB, PHASE, QBOGEN, RAND, RIG, RTERP, SCIMOD, SPHERE, STDATM, and WIND. The setup segment should contain: GETNMC, RTRAN, and SETUP. The Jacchia segment should contain: FAIR, JAC, JACCH, TINF, and TME. The 4-D segment should contain: ADJUST, CHECK, DIAGEQ, GEN4D, GRID4D, GROUP, INTER4,

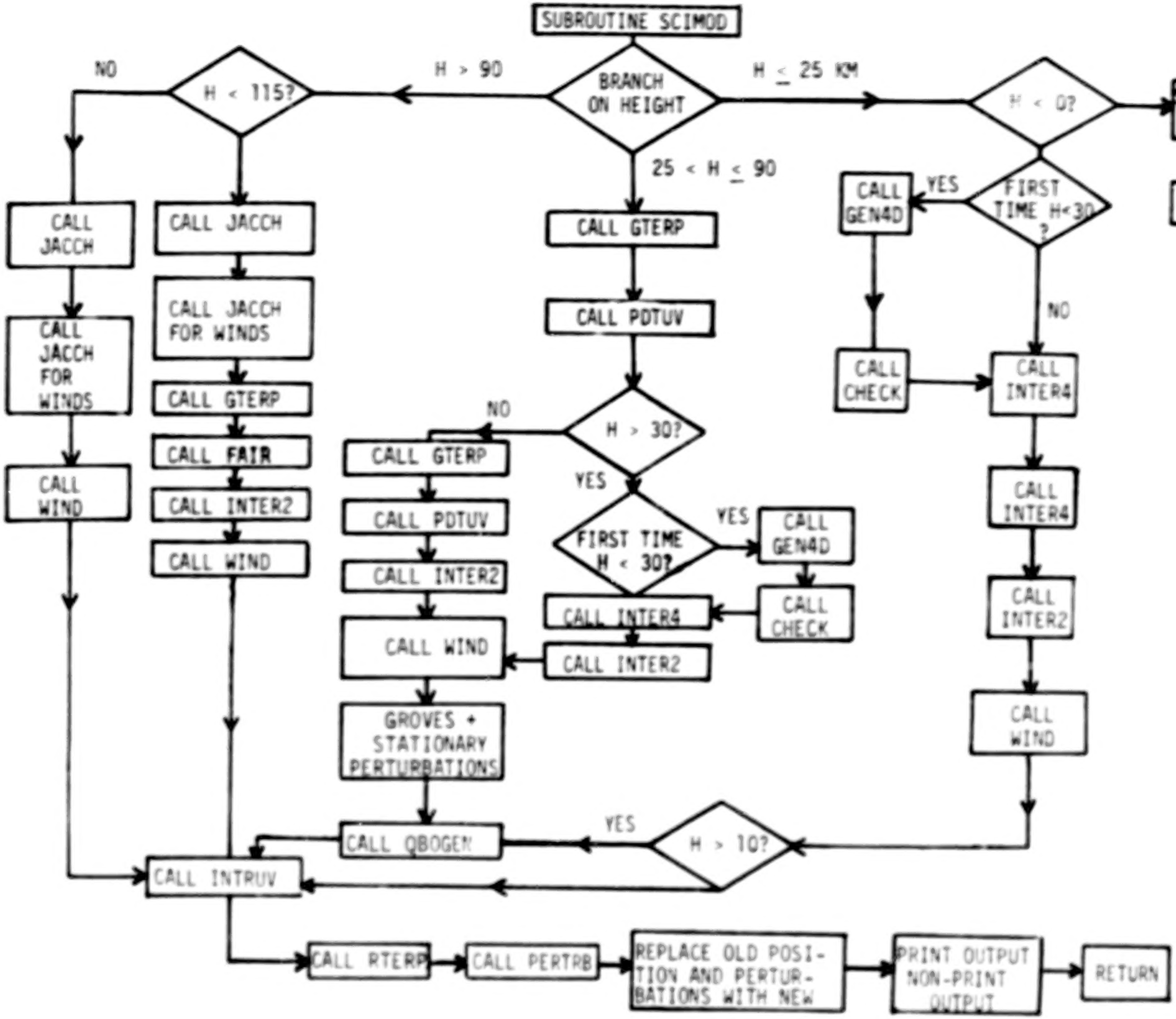


Figure 5.2: An abbreviated flow chart of the SCIMOD subroutine.

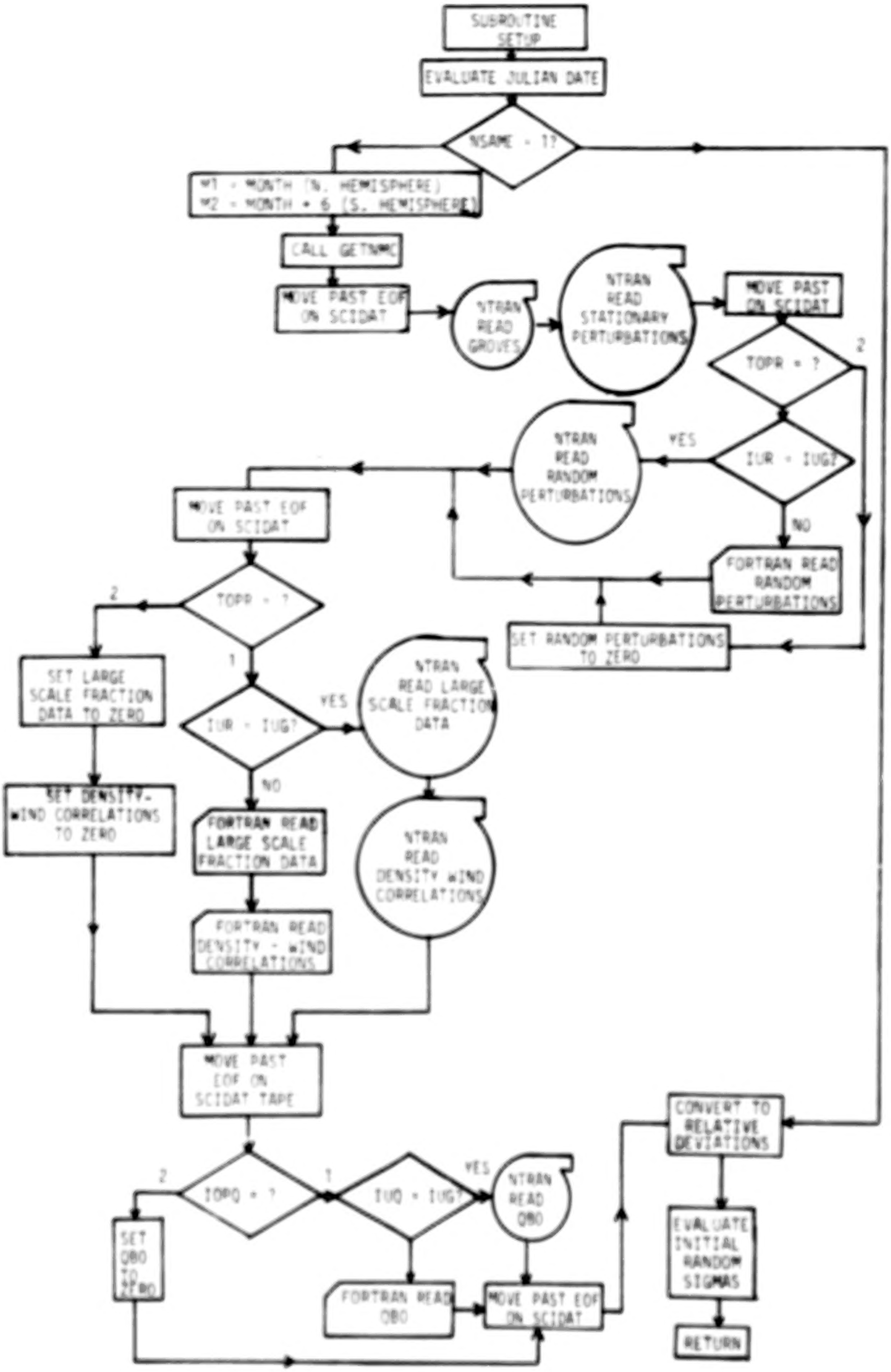

SUBROUTINE SETUP
EVALUATE JULIAN DATE
NSAME = 1?
M1 = MONTH (N. HEMISPHERE)
M2 = MONTH + 6 (S. HEMISPHERE)
CALL GETNMC
MOVE PAST EOF ON SCIDAT
NTRAN READ GROVES
NTRAN READ STATIONARY PERTURBATIONS
MOVE PAST ON SCIDAT
TOPR = ?
2
IUR = IUG?
YES
NO
NTRAN READ RANDOM PERTURBATIONS
FORTRAN READ RANDOM PERTURBATIONS
SET RANDOM PERTURBATIONS TO ZERO
MOVE PAST EOF ON SCIDAT
TOPR = ?
2
1
SET LARGE SCALE FRACTION DATA TO ZERO
IUR = IUG?
YES
NO
NTRAN READ LARGE SCALE FRACTION DATA
SET DENSITY-WIND CORRELATIONS TO ZERO
FORTRAN READ LARGE SCALE FRACTION DATA
NTRAN READ DENSITY WIND CORRELATIONS
FORTRAN READ DENSITY - WIND CORRELATIONS
MOVE PAST EOF ON SCIDAT TAPE
CONVERT TO RELATIVE DEVIATIONS
2
TOPQ = ?
1
IUQ = IUG?
YES
NTRAN READ QBO
SET QBO TO ZERO
EVALUATE INITIAL RANDOM SIGMAS
FORTRAN READ QBO
MOVE PAST EOF ON SCIDAT
RETURN

Figure 5.3: Abbreviated flow chart of the SETUP subroutine.

INTLL, INTRP4, SELEC4, and SORT4. The following MAP statement for file GRAM to create absolute element ABS will accomplish the mapping of the program with these segments setup as described:

```
@MAP, IS . GRAM. ABS
   IN GRAM. CORLAT,  .  GRAM,  .  GTERP,  .  INTERW,  .  INTERZ
   IN GRAM. INTER2,  .  INTRUV,  .  NORMAL,  .  PDTUV,  .  PERTRB,  .  PHASE
   IN GRAM. QBOGEN,  .  RAND,  .  RIG,  .  RTERP
   IN GRAM. SCIMOD,  .  SPHERE,  .  STDATM,  .  WIND
   NOT TPF$
   SEG SETUP*
   IN GRAM.  GETNMC,  .  RTRAN,  .  SETUP
   NOT TPF$
   SEG JACCH*,  SETUP
   IN GRAM.  FAIR,  .  JAC,  .  JACCH,  .  TINF,  .  TME
   NOT TPF$
   SEG SEG4D*,  SETUP
   IN GRAM.  ADJUST,  .  CHECK,  .  DIAGEQ
   IN GRAM.  GEN4D,  .  GRID4D,  .  INTER4,  .  INTLL,  . INTRP4
   IN GRAM.  SELEC4,  .  SORT4,  .  GROUP
   NOT TPF$
   END
```

This segmented map saves approximately 4 K (decimal) in core storage, but does not significantly affect run time, since the segments being overlayed (the setup, Jacchia, and 4-D segments) only have to be loaded in once during any given trajectory or profile evaluation. If further reduction in size is desired the 4-D segment can be subdivided into two parts, one containing only CHECK, GROUP, INTER4, and INTLL and another segment containing ADJUST, DIAGEQ, GEN4D, GRID4D, INTRP4, SELEC4 and SORT4. This saves another 1 K in storage, approximately.

Some characteristics of some of the subroutines in each of these segments are described more fully in the following sections.

5.2: The Primary Section

This section consists of the main program segment GRAM, the SCIMOD subroutine, the subroutines for evaluating Groves values, the stationary perturbations, the QBO and random perturbations, and general interpolation subroutines. With the exception of GRAM and SCIMOD the parts of this section were adequately described in the previous section.

Many of the subroutines transfer their input and output via COMMON statements. This procedure saves much in core storage space. The discussion in this and subsequent sections describes the input and output of some of the subroutines, both by argument lists and via COMMON statements.

Main Segment GRAM. This program serves as a driver for the SETUP and SCIMOD subroutines (see Figure 4.1). It reads one card, the first input card, in free field format. This card contains:

1.	The initial height	H1
2.	The initial latitude (degrees)	PHI1
3.	The initial west longitude (degrees)	THET1
4.	The F10.7 solar flux	F10
5.	The 81 day mean F10.7 solar flux	F10B
6.	The a_p geomagnetic index	AP
7-9.	The date month/date/2 digit year	MN/IDA/IYR
10-12.	The Greenwich time hours: minutes: seconds	IMRO; MINO; ISECO
13-15.	The latitude, longitude, and height increments	DPHI, DTHET, DH
16.	The maximum number of profile positions	NMAX
17.	The time increment between profile positions	INCT
18.	The trajectory option	IOPT
19	The output option	IOPP
20.	The minimum geostrophic latitude	GLAT

The trajectory input records (if used) are also read by GRAM, after control has returned from SETUP, which reads the second and third initial data input cards. See Section 4.4 and Appendix C for further description of the card input.

The COMMON "IOTEMP" transfers data from the card input in GRAM to the other subroutines called by GRAM (SETUP, SCIMOD, and RIG).

Subroutine SCIMOD. This program is the primary subroutine of the GRAM program. It serves as a driver for all of the various sections of the atmospheric evaluation. See Figure 5.2 for a flow chart of this subroutine.

The input to SCIMOD, transferred by COMMON statements IOTEMP and PDTCOM, is:

1.	Acceleration of gravity (m/sec^2)	G
2.	Earth radius to height H (km)	RI
3.	Height (km)	H
4.	Latitude (radians)	PHIR
5.	Longitude (radians)	THETR
6.	F10.7 solar flux	F10
7.	Mean F10.7 solar flux	F10B
8.	Geomagnetic index a_p	AP
9-11.	Date	MN/IDA/IYR
12-14.	Time	IHR: MIN: ISEC
15.	Previous height (km)	H1
16.	Previous latitude (radians)	PHI1R
17.	Previous longitude (radians)	THET1R
18-20.	Previous random pressure, density, and temperature perturbations (%), large scale (L) and small scale (S)	RP1L, RD1L, RT1L, RP1S, RD1S, RT1S
21-23.	Previous random pressure, density, and temperature standard deviations (%), large scale (L) and small scale (S)	SP1L, SD1L, ST1L, SP1S, SD1S, ST1S

24-25.	Previous random winds (m/s), large scale (L) and small scale (S)	RU1L, RV1L, RU1S, RV1S
26-27.	Previous standard deviation of random winds (m/s), large scale (L) and small scale (S)	SU1L, SV1L, SU1S, SV1S

The COMMON "PDTCOM" contains data transferred into SCIMOD from SETUP. The COMMON "IOTEMP" transfers data in from GRAM. The COMMON "C4" transfers data out to the 4-D section of the program. The COMMON "COMPER" transfers data out to the random perturbation subroutines.

The SCIMOD subroutine prints and (optionally) punches on a non-print output file, the output described in Section 4 and Appendix C. It also transfers output to other subroutines via the above-mentioned COMMON lists. The SCIMOD subroutine updates the profile or trajectory positions by setting the current position equal to the previous position before exit. The previous position information then stays in the COMMON list unit the next call to SCIMOD. The previous random perturbations are handled in similar fashion.

5.3 The Setup Section

The function of the setup section of the program is to load the initial data and the data from the SCIDAT tape. See Figure 4.1 for a flow chart illustrating how the SETUP subroutine fits into the overall program and Figure 5.2 for a flow chart of the SETUP subroutine.

The SETUP subroutine reads the second and third cards of input. The second cards contains:

1.	Groves input unit	IUG
2.	Random input unit	IUR
3.	QBO input unit	IUQ
4.	4-D input unit	IU4
5.	Random option	IOPR

6.	QBO option	IOPQ
7.	First random number	NR1
8.	NMC read option	NMCOP
9.	4-D scratch unit	IOTEM1
10.	NMC grid point scratch unit	IOTEM2

The third card (optional, read only if IOPR = 1) contains:

1-6.	Initial random perturbations in pressure, density, and temperature (%), large scale (L) and small scale (S)	RP1L, RD1L, RT1L RP1S, RD1S, RT1S
7-10.	Initial random wind perturbation (m/s), large scale (L) and small scale (S)	RU1L, RV1L, RU1S, RV1S

The COMMON list "PDTCOM" transfers the arrays, loaded with the approriate data from the SCIDAT data tape, to the other subroutines. This COMMON list contains the following arrays:

1-3.	Groves pressure, density, and temperature	PG, DG, TG
4-6.	Stationary perturbations in pressure, density, and temperature	PSP, DSP, TSP
7-11.	Amplitudes of QBO pressure, density, and temperature, and winds	PAQ, DAQ, TAQ, UAQ, VAQ
12-16.	Phases of QBO pressure, density, and temperature, and winds	PDQ, DDQ, TDQ, UDQ, VDQ
17-21.	Standard deviations for the random pressure, density, temperature and winds	PR, DR, TR, UR, VR

The COMMON list "COTRAN" is used to transfer data to setup from the NTRAN read subroutine RTRAN, which has multiple entry points for various different types of data from the SCIDAT data tape. The COMMON "CHIC" is used to transfer the spherical harmonics coefficients to the SPHERE subroutine.

5.4 The Jacchia Section

The subroutine JACCH calculates the pressure, density, and temperature at a point in space for heights above 90 km for a particular time.

1. Height in km	H
2. Latitude in radians	PHIR
3. West longitude in degrees (0 to 360 degrees)	THET
4. Solar radio noise flux F10.7 (10^{-22} watts/m^2)	F10
5. 81 - day average solar flux F10.7	F10B
6. Geomagnetic index a_p	AP
7. Month	MN
8. Day of month	IDA
9. Year	IYR
10. Hour of day in universal time	IHR
11. Minute of hour in universal time	MIN
12. Mean Julian day	XMJD

The outputs are:

1. Pressure in units of nt/m^2	PH
2. Density in units of kg/m^3	DH
3. Temperature in Kelvin degrees	TH

The theory and methods used in JACCH for calculating the pressure, density, and temperature are given in Jacchia, (1970). A brief explanation will be given below.

The subroutine JACCH consists of four sections: the main routine and three imbedded subroutines. All sections have numerous comments to explain each part of the program.

Main Routine (JACCH). The main routine acts as the calling routine, and also, calculates the seasonal - latitudinal variations in the lower thermosphere.

The seasonal - latitudinal density variations are given by equation

(2.1) of Justus et al (1974 a).

The equations for the molecular weight and the relative temperature were given as equations (2.2) and (2.3) of Justus et al (1974 a). After the density, temperature, and molecular weight are calculated, the pressure is calculated from the ideal gas law:

$$P = \frac{\rho RT}{M}$$

where ρ is the density, R is the universal gas constant, T is the temperature, and M is the molecular weight.

An option is included in the main routine whereby the yearly mean values of the density, pressure, and temperature may be calculated directly. If the value of the month input variable is thirteen, (MN = 13), the exosphere temperature is immediately set equal to 1000° K (which is the recommended design value for annual mean conditions) and the yearly mean density, pressure, and temperature values are calculated. Note that the 1962 U.S. Standard Atmosphere has an exospheric temperature of approximately 1500° K and is thus considerably different from the 1000° K results of the annual mean in the PROFILE program.

Subroutine TME. This subroutine calculates variables necessary for input into the subroutine TINF. The input variables are:

1.	month (month = 13 denotes annual mean and bypasses this subroutine)	MN
2.	day of month	IDA
3.	year	IYR
4.	hour of day in universal time	IHR
5.	minute of day in universal time	MIN
6.	mean Julian day	XMJD

7.	latitude in radians	XLAT
8.	longitude in degrees (input: 0 to 360 degrees turning westward; output: -180 to + 180 degrees)	XLONG

The output variables are:

1.	solar declination angle in radians	SDA
2.	solar hour angle in radians	SHA
3.	day number from January 1	DD
4.	day number divided by tropical year (365.2422 days)	DY

Subroutine TINF. This subroutine calculates the exospheric temperature. The input variables are:

1.	solar radio noise flux (10^{-22} watts/m^2)	F10
2.	81 - day average F10	F10B
3.	geomagnetic latitude in radians	XLAT
4.	solar declination angle	SDA
5.	solar hour angle	SHA
6.	day number divided by tropical year	DY
7.	diurnal factor equal to 0.31	R

The output is the exospheric temperature, TE. Factors included in the calculation of the exospheric temperature are solar activity variations, diurnal variations, variations with the geomagnetic activity, and semi-annual variations.

Subroutine JAC. This subroutine calculates the molecular weight, density, and temperature without the seasonal - latitudinal variations. The input variables are:

1.	height in km	Z
2.	exospheric temperature	T

The output variables are:

1. temperature	TZ
2. molecular weight	EM
3. density	DENS

5.5 The 4-D Section

GRID4D and subroutines SØRT4, INTRP4 and SELEC4 are basically the MAIN PRØGRAM, SØRT, INTERP and INPUT as documented in the 4-D users reference manual and subsequent updates.

Some changes have been made.

In GRID4D, NTRAN MØVE statements are used to select the appropriate file for a given month on the 4-D data tape mounted on UNIT IT in the UNIVAC version. In Georgia Tech's CDC version, and on other machines, separate reads for each record must be used until an end of file is reached, and reading continues until the proper file is found. If a parity error is encountered in reading IT, a message

"INPUT UNIT NO. IT IN ERRØR FØR RECØRD NØ IRC"

is printed - execution continues. Such an error will only be of consequence if the particular record read in error is required for interpolation.

Grid point profiles for subsequent interpolation are tagged and filed on a dynamically assigned scratch UNIT SCRCH1 (IØTEM1 in calling program), instead of occupying core as in the 4-D model.

Any error in the handling of the 4-D data tape or UNIT SCRCH(IØTEM1 in calling program) by TRID4D which results in a transfer to

STATEMENT NO. 30

is fatal, and results in the printing of an error message and termination of execution (see Section 4.5).

Slight changes have been made to the logic of S0RT4 in the interests of efficiency.

SELEC4 is concerned only with the selection of the record numbers of the appropriate interpolation profiles.

GETNMC has been added to file the NMC grid point data, read either from cards of the SCIDAT data tape on UNIT IUG, on a dynamically assigned scratch file SCRCH2 (IOTEM2 in calling program), instead of occupying 1977 words of core as in the 4-D model. If other than 1977 records are filed, an error message

"N REC0RDS WRITTEN BY GETNMC ON SCRATCH FILE M"

is printed and execution terminated.

INTRP4 uses a modified latitude - longitude interpolation scheme in the mixed NMC - equatorial, equatorial and southern hemisphere regions.

The dimensions of some variables have been altered in keeping with the maximum number of profiles to be used in interpolation (16 instead of 25 as in the 4-D model), and to provide the index word for each record of SCRCH1 (IN (107) instead of (106)).

All references to, and subroutines associated with, the determination of the coefficients of the best fit polynomials to the selected profiles, as performed in the original 4-D model, have been deleted. All vertical interpolations required are performed by SCIM0D.

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APPENDIX A

THE SPHERICAL HARMONIC WIND MODEL

The spherical harmonic wind model is based on the second order spherical harmonic expansion relation (equation 2.12)

$$\begin{aligned} u(m, z, \theta, \phi) = {} & a_1 + a_2 \cos\phi + a_3 \cos\theta \sin\phi \\ & + a_4 \sin\theta \sin\phi + a_5 (3\cos^2\phi - 1)/2 \\ & + a_6 \cos\theta (3 \sin\phi \cos\theta) + a_7 \sin\theta (3 \sin\phi \cos\phi) \\ & + a_8 (2 \cos^2\theta - 1)(3 \sin^2\phi) + a_9 (2 \sin\theta \cos\theta)(3 \sin^2\phi) \end{aligned} \tag{A-1}$$

where u is the eastward wind component (or a similar equation for v, the northward component), m is the month, z is the height, θ is the longitude, and ϕ is the co-latitude. The coefficients (a's) must be estimated from observed data, as a function of month and height. Five kilometer height intervals were selected at which to evaluate the coefficients.

Estimation of the Model Coefficients

The spherical harmonic model may be expressed as a linear function by the transformation

$$\begin{aligned} x_1 &= 1 \\ x_2 &= \cos\phi \\ x_3 &= \cos\theta \sin\phi \\ x_4 &= \sin\theta \sin\phi \\ x_5 &= 3(\cos^2\phi - 1)/2 \end{aligned}$$

$$x_6 = \cos\theta\ (3 \sin\phi \cos\phi)$$

$$x_7 = \sin\theta\ (3 \sin\phi \cos\phi) \qquad \text{(A-2)}$$

$$x_8 = (2 \cos^2\theta - 1)\ (3 \sin^2\phi)$$

$$x_9 = (2 \sin\theta \cos\theta)\ (3 \sin^2\phi)$$

Using this transformation, the model becomes

$$u = \sum_{i=1}^{9} a_i x_i = \underline{A} \cdot \underline{X} \qquad \text{(A-3)}$$

where $\underline{A}$ and $\underline{X}$ are 9-component vectors with components a_i and x_i, respectively. If similar coefficient b_i are defined for v, the northward component, its representation becomes

$$v = \underline{B} \cdot \underline{X}$$

Since the wind components vary with month and height, the A and B vectors will depend on month and height. Over altitudes 25 to 65 km the all a component of the A and B coefficient vectors are evaluated every 5 km, for each month. Above 65 km, where fewer wind observations were available, a 5 km height increment was still used, but only the 1st-order coefficients (1-4) were evaluated; the 2nd-order coefficients (5-9) were set identially to zero (see the printout of the spherical harmonic in the SCIDAT tape listing of Appendix B).

The least-squared error approach (Draper and Smith, 1966) was used to estimate the coefficient vectors A and B.

The Data

Four sources of wind data were available for this analysis. The most extensive source was the SUMS tape from the World Data Center (NOAA, 1976). This tape contained monthly wind data averaged over the period 1969 to 1976. Up to 20 stations around the world reported winds in the altitude range 25 to 90 km. These stations were located primarily in the Western hemisphere.

Data from three Eastern hemisphere stations--Thumba, India; Volograd, USSR; and Heiss Island--were available (NASA, 1978). This also was monthly averaged data ranging from 25 to 60 km.

The third source of data was grenade soundings from four locations: Point Barrow, Alaska; Wallops Island, Virginia; Fort Churchill, Canada; and Natal/Ascension Island (Theon, et al., 1972). The Natal/Ascension data were annual means; the other stations were averaged over three seasons: summer, winter, and Equinox. A sinusoidally weighted interpolation scheme was used to estimate monthly wind averages. In this scheme, the summer and winter observations were assumed to be the extremes, and the equinox was the nominal wind value.

The fourth data source was from Woomera, Australia (Pearson and Johnson, 1973). Monthly average wind components from 30 to 80 km were available from this source.

The four data sources were combined and used as input to a multiple regression program for estimating the spherical harmonics coefficients, as previously described. Monthly wind averages based on less than three observations were filtered from the data.

Very little southern hemisphere wind data were available, resulting in eratic wind prediction at southern latitudes. To alleviate this problem, data from the northern hemisphere was used as southern hemisphere data, displaced by 6 months, with both latitude and longitude reversed.

The number of stations which had enough wind data for meaningful averages varied considerably from one month to the next and from one altitude to the next. There was a maximum of 23 stations and a minimum of 5 stations at a given height. The geographic distribution of the stations was strongly biased towards the north-west quarter-sphere. These factors, along with the large variance in the wind data result in the spherical harmonics coefficients having large standard deviations. As a result of this, increased emphasis should be placed on perturbation analysis available in the GRAM program. As more and better wind data becomes available, the spherical harmonics model coefficients may be updated, and better results obtained.

The spherical harmonic model is used at all latitudes to calculate winds between the heights of 25 and 95 km. Between 20 and 25 km and between 90 and 95 km, a Fairing technique is used to smooth the winds between the spherical harmonic model values and the geostrophic winds. At low latitudes (below the "minimum geostrophic latitude" given in the input), the geostrophic relation is not used. Instead interpolation is done between plus and minus minimum geostrophic latitude (below 25 km and above 90 km only).

APPENDIX B

LISTING OF THE REVISED TAPE "SCIDAT-MOD-3" FOR THE GRAM PROGRAM

The tape contains the following data, identified by code characters at the beginning of each record. Month 13 refers to annual mean values. For code P, D, T, S, R and RW data, southern latitudes are given by northern hemisphere data displaced six months. Annual mean data and the QBO parameters are the same for both southern and northern hemispheres. For a more complete discussion of the input data, see Section 4.2.

Code	Data	Description
N	NMC Grid Data	Same as NMC Grid Required by NASA version 4-D program. Data consists of sequential point number followed by the two corresponding NMC grid indices. There are five points per record on the tape.
P	Groves Pressure (nt/m^2)	Month, height, values at latitudes 0, 10, 20, ... 90 exponent. Same format as in Groves report.
D	Groves Density (kg/m^3)	
T	Groves Temperature (°K)	
S	Stationary Perturbations in monthly means (per mill)	Month, height, longitude, Δp at north latitude, 10, 30, 50, 70, 90, Δp same, ΔT same.
R	Random pressure, density and temperature perturbation magnitudes (per mill)	Month, height, Δp at north latitude 10, 30, 50, 70, 90, $\Delta \rho$ same, ΔT same
RW	Random magnitudes wind perturbation (m/s)	Month, height, Δu at north latitude 10, 30, 50, 70, 90, Δv same
P	Fractional variance in large scale thermodynamic variables	13 (Annual), height, fractional variance in large scale per mill for pressure, density and temperature, each at latitude 10°, 30°, 50°, 70°, 90°
PW	Fractional variance in large scale winds	13 (Annual), height, fractional variance in u at 10°, 30°, 50°, 70°, 90° latitude, same for v

Code	Data	Description
CS	Small scale density-velocity correlations	13 (Annual), height, $<\rho u>_S$ at 10°, 30°, 50°, 70°, 90° latitude, same for $<\rho v>$
CL	Large scale density-velocity correlations	13 (Annual), height, $<\rho u>_2$ at 10°, 30°, 50°, 70°, 90° latitude, same for $<\rho v>_L$
QP	QBO pressure parameters-amplitude (per mill) and phase (days after Jan. 0, 1966 when 1st maximum occurs)	Height, amplitude and phase at 10° latitude, amplitude and phase at 30° ... , amplitude and phase at 90°
QD	QBO density parameters (as in QP)	
QT	QBO temperature parameters	
QU	QBO eastward wind parameters-amplitude (0.1 m/s) and phase (days after Jan. 0, 1966)	
QV	QBO northward wind parameters - (as in QU)	
SP	Spherical harmonic coefficient	Height, month, and coefficient values a_1-a_9, cm/s.

The tape consists of six FORTRAN readable files with an end of file marker after each file. The first file contains the NMC grid data, the second contains the Groves and Stationary perturbation data, the third contains the random perturbation data, the fourth contains the fractional large scale variances and the density-velocity correlations, and the fifth contains the QBO data. Each record of the NMC grid data file contains the code (N) and x-y coordinates for 5 points. The Format is (A2, 15I7). The total number of NMC grid points is 1977. The NMC grid data file contains a total of 396 records, with the last record containing points 1976 and 1977 and zeros for the remaining values. The format for the Groves data is (A2, 13I7).

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for the stationary perturbation it is (A2, 18I7), for the code-R data it is (A2, 17I7), for the code RW data it is (A2, 12I7), for the large scale fractional variances in thermodynamic variables it is (A2, 17I7), for the large scale fractional wind variances it is (A2, 12I7) for the density-velocity correlations (small scale and large scale) it is (A2, 12I7), and for the quasi-biennial data it is (A2, 11I7), and for the spherical harmonic it is (A2, 11I7). The Groves data contains 702 records, the stationary perturbation data contains 1248 records, the code R random data contains 260 records, the code RW random winds data contain 325 records, the code P large scale fractional variances contain 25 records, the code PW large scale fractional wind variances contain 25 records, and code CS and CL density-velocity correlation data contain 25 records each, the QBO data contain 80 records, and the spherical harmonics data contain 336 records.

Following is a listing of the data contained on the SCIDAT tape.

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*** NMC GRID DATA***
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N    11    25     1    12    26     1    13    27     1    14    28     1    15    29     1
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N    21    15     2    22    16     2    23    17     2    24    18     2    25    19     2
N    26    20     2    27    21     2    28    22     2    29    23     2    30    24     2
N    31    25     2    32    26     2    33    27     2    34    28     2    35    29     2
N    36    30     2    37    31     2    38    32     2    39    33     2    40    34     2
N    41    13     3    42    14     3    43    15     3    44    16     3    45    17     3
N    46    18     3    47    19     3    48    20     3    49    21     3    50    22     3
N    51    23     3    52    24     3    53    25     3    54    26     3    55    27     3
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N    76    24     4    77    25     4    78    26     4    79    27     4    80    28     4
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P	13	65	123	122	120	115	111	109	106	102	100	99	-1
P	13	70	576	576	570	545	525	518	513	489	462	453	-2
P	13	75	256	258	258	247	237	236	236	224	202	195	-2
P	13	80	111	112	113	108	103	102	103	98	88	85	-2
P	13	85	482	486	488	460	433	425	428	405	375	365	-3
P	13	90	206	208	207	193	178	173	174	164	152	147	-3
P	13	95	877	882	877	814	752	724	723	678	626	608	-4
P	13	100	384	386	385	359	334	322	321	300	276	268	-4
P	13	105	182	182	181	169	158	153	154	143	132	128	-4
P	13	110	960	959	943	873	811	792	801	748	690	669	-5
D	1	25	400	393	392	381	377	382	395	403	408	409	-4
D	1	30	178	175	173	171	171	176	179	176	174	174	-4
D	1	35	820	815	805	800	791	812	813	772	747	739	-5
D	1	40	404	400	386	374	367	371	361	338	324	320	-5
D	1	45	207	203	196	189	180	177	168	153	144	141	-5
D	1	50	108	107	104	100	94	89	81	72	67	65	-5
D	1	55	585	581	575	554	511	467	420	367	335	325	-6
D	1	60	327	325	320	302	277	248	218	192	176	171	-6
D	1	65	182	179	174	164	146	131	115	100	91	88	-6
D	1	70	952	926	906	837	755	661	581	497	447	430	-7
D	1	75	444	431	421	403	365	330	289	241	212	203	-7
D	1	80	195	190	187	180	171	157	137	110	94	88	-7
D	1	85	850	832	809	791	760	722	634	503	424	398	-8

D	1	90	370	365	349	339	333	320	283	225	190	179	-8
D	1	95	148	146	139	138	141	143	131	103	86	81	-8
D	1	100	580	574	560	571	622	645	593	474	403	379	-9
D	1	105	242	236	234	244	271	294	278	224	192	181	-9
D	1	110	108	106	104	107	119	128	124	101	87	83	-9
D	2	25	400	393	386	379	382	391	387	377	371	369	-4
D	2	30	178	174	172	171	173	178	175	168	164	162	-4
D	2	35	823	813	799	791	790	799	804	765	742	734	-5
D	2	40	403	393	386	375	368	366	366	348	337	334	-5
D	2	45	205	201	195	187	181	176	173	162	155	153	-5
D	2	50	108	106	104	99	95	90	85	77	72	71	-5
D	2	55	591	592	580	545	521	483	446	390	356	345	-6
D	2	60	334	332	325	303	284	261	235	203	184	177	-6
D	2	65	182	181	174	161	149	136	122	105	95	91	-6
D	2	70	943	914	873	809	760	694	612	516	458	439	-7
D	2	75	444	425	408	382	364	338	300	243	209	197	-7
D	2	80	198	189	185	177	171	160	141	111	93	87	-7
D	2	85	845	812	817	785	766	738	654	494	398	366	-8
D	2	90	360	343	347	342	341	331	295	222	178	164	-8
D	2	95	147	140	139	137	142	145	133	99	79	72	-8
D	2	100	610	571	574	574	598	619	578	439	356	328	-9
D	2	105	264	246	249	247	257	266	254	195	160	148	-9
D	2	110	125	114	114	113	116	118	114	89	74	69	-9
D	3	25	399	387	388	380	381	390	381	354	338	332	-4
D	3	30	178	175	174	172	174	177	173	162	155	153	-4
D	3	35	827	811	805	802	797	795	785	755	737	731	-5
D	3	40	400	397	390	382	371	368	365	356	351	349	-5
D	3	45	204	202	198	191	183	180	177	170	166	164	-5
D	3	50	109	109	106	101	96	94	90	84	80	79	-5
D	3	55	605	604	591	555	524	509	479	439	415	407	-6
D	3	60	340	343	331	305	288	276	258	233	218	213	-6
D	3	65	185	182	174	161	150	145	134	121	113	111	-6
D	3	70	931	912	863	800	760	735	668	594	550	535	-7
D	3	75	440	417	400	384	368	358	325	282	256	248	-7
D	3	80	195	186	183	177	174	172	155	129	113	108	-7
D	3	85	841	793	803	796	778	776	724	589	508	481	-8
D	3	90	361	345	350	345	340	346	323	255	214	201	-8
D	3	95	153	140	142	139	138	141	136	108	91	86	-8
D	3	100	644	591	583	574	578	589	559	451	386	365	-9
D	3	105	279	249	247	248	247	251	241	200	175	167	-9
D	3	110	131	117	114	110	110	112	111	94	84	80	-9
D	4	25	399	394	386	383	379	378	375	376	377	377	-4
D	4	30	178	178	174	174	173	173	173	174	175	175	-4
D	4	35	829	823	822	814	798	793	802	793	798	786	-5
D	4	40	406	406	402	396	384	381 –	377	364	356	354	-5
D	4	45	208	208	205	198	192	192	187	175	168	165	-5
D	4	50	112	112	110	106	103	103	98	89	84	82	-5
D	4	55	623	622	610	582	563	565	541	485	451	440	-6
D	4	60	352	350	340	323	311	314	294	264	246	240	-6
D	4	65	189	186	179	168	164	165	155	139	129	126	-6
D	4	70	958	942	903	864	838	846	788	697	642	624	-7
D	4	75	440	435	435	416	409	412	389	341	312	303	-7
D	4	80	193	190	196	196	195	200	186	162	148	143	-7
D	4	85	826	821	864	872	871	889	853	730	656	632	-8

D	4	90	368	364	382	388	373	374	353	301	270	259	-8
D	4	95	159	157	163	159	147	139	135	115	103	99	-8
D	4	100	673	648	669	654	603	560	522	445	399	383	-9
D	4	105	282	265	269	265	253	234	223	192	173	167	-9
D	4	110	126	116	115	114	108	107	106	95	88	86	-9
D	5	25	396	400	391	389	384	381	385	398	406	408	-4
D	5	30	178	180	177	177	177	176	178	181	183	183	-4
D	5	35	829	832	835	830	816	811	823	857	877	884	-5
D	5	40	411	414	411	402	396	395	399	399	399	399	-5
D	5	45	212	212	209	204	202	201	201	200	199	199	-5
D	5	50	113	114	112	109	109	110	109	104	101	100	-5
D	5	55	621	628	624	608	605	616	606	586	574	570	-6
D	5	60	350	351	344	334	338	344	341	324	314	310	-6
D	5	65	193	191	184	180	179	184	183	178	175	174	-6
D	5	70	984	985	958	930	935	957	945	906	883	875	-7
D	5	75	444	458	465	457	456	469	466	467	468	468	-7
D	5	80	191	200	208	207	211	221	225	224	223	223	-7
D	5	85	838	872	897	894	903	941	978	990	997	1000	-8
D	5	90	384	383	390	375	366	365	372	365	361	359	-8
D	5	95	163	166	166	151	131	119	119	122	124	124	-8
D	5	100	663	670	665	602	510	439	424	422	421	420	-9
D	5	105	262	266	270	246	210	178	173	178	181	182	-9
D	5	110	111	112	115	107	94	85	85	88	90	90	-9
D	6	25	397	400	395	392	396	399	397	403	407	408	-4
D	6	30	177	178	180	181	182	183	183	187	189	190	-4
D	6	35	828	835	845	848	848	851	870	897	913	919	-5
D	6	40	411	413	412	414	413	416	426	436	442	444	-5
D	6	45	210	211	209	209	210	215	219	223	225	226	-5
D	6	50	111	112	111	112	114	117	119	120	121	121	-5
D	6	55	606	617	619	622	631	649	669	673	675	676	-6
D	6	60	339	341	343	347	356	368	379	380	381	381	-6
D	6	65	187	189	188	188	193	202	209	213	215	216	-6
D	6	70	98	99	97	97	100	106	110	113	115	115	-6
D	6	75	447	463	458	461	474	511	547	580	600	606	-7
D	6	80	193	202	204	204	211	232	257	275	286	289	-7
D	6	85	85	87	87	86	87	94	104	113	118	120	-7
D	6	90	384	380	372	355	335	333	350	365	374	377	-8
D	6	95	160	158	152	134	109	96	99	105	109	110	-8
D	6	100	636	633	616	535	412	330	328	345	355	359	-9
D	6	105	252	256	252	224	171	136	132	140	145	146	-9
D	6	110	106	109	113	104	83	67	66	69	71	71	-9
D	7	25	400	399	401	402	408	407	407	413	417	418	-4
D	7	30	178	179	182	185	186	187	190	194	196	197	-4
D	7	35	820	840	856	863	881	891	903	919	929	932	-5
D	7	40	404	410	415	419	428	437	444	452	457	458	-5
D	7	45	207	208	209	211	217	226	230	231	232	232	-5
D	7	50	108	109	111	112	116	121	125	125	125	125	-5
D	7	55	585	591	609	615	641	672	695	700	703	704	-6
D	7	60	327	328	338	343	357	374	393	400	404	406	-6
D	7	65	182	183	186	188	195	207	219	225	229	230	-6
D	7	70	95	95	95	95	100	108	117	122	125	126	-6
D	7	75	444	446	440	434	468	524	587	625	648	655	-7
D	7	80	195	196	195	191	203	231	265	291	307	312	-7
D	7	85	85	85	84	80	82	89	103	113	119	121	-7

D	7	90	370	370	358	329	302	297	314	332	343	346	-8
D	7	95	148	148	142	122	102	90	91	94	96	96	-8
D	7	100	580	591	581	500	399	333	310	305	302	301	-9
D	7	105	242	247	245	215	178	143	130	125	122	121	-9
D	7	110	108	112	113	103	86	70	62	58	56	55	-9
D	8	25	400	403	406	406	408	403	411	423	430	433	-4
D	8	30	178	179	184	185	188	188	192	196	198	199	-4
D	8	35	823	845	853	872	882	895	907	924	934	938	-5
D	8	40	403	410	417	420	429	440	445	445	445	445	-5
D	8	45	205	208	206	210	219	225	227	225	224	223	-5
D	8	50	109	108	110	111	117	120	122	120	119	118	-5
D	8	55	591	593	594	609	642	666	673	665	660	659	-6
D	8	60	334	326	330	336	353	370	379	373	369	368	-6
D	8	65	182	182	179	182	192	201	208	207	206	206	-6
D	8	70	94	93	93	92	96	102	110	112	113	114	-6
D	8	75	444	455	440	431	445	488	542	568	584	589	-7
D	8	80	198	203	202	194	197	216	244	261	271	275	-7
D	8	85	85	90	89	85	82	84	91	101	107	109	-7
D	8	90	360	384	390	351	305	287	293	321	338	343	-8
D	8	95	147	161	158	139	114	101	96	99	101	101	-8
D	8	100	610	658	659	583	479	408	360	349	342	340	-9
D	8	105	264	287	281	252	214	182	154	142	135	132	-9
D	8	110	125	133	129	112	96	81	68	62	58	57	-9
D	9	25	399	400	399	400	401	403	401	407	411	412	-4
D	9	30	178	180	181	185	185	185	186	188	189	190	-4
D	9	35	827	841	854	863	873	872	871	873	874	875	-5
D	9	40	400	406	412	415	418	424	422	416	412	411	-5
D	9	45	204	206	208	208	211	214	212	205	201	199	-5
D	9	50	109	109	110	109	112	114	113	108	105	104	-5
D	9	55	605	600	606	600	620	631	616	587	570	564	-6
D	9	60	340	336	328	326	340	347	339	323	313	310	-6
D	9	65	185	181	179	175	178	183	182	175	171	169	-6
D	9	70	931	945	939	895	880	903	932	922	916	914	-7
D	9	75	440	460	468	432	409	419	451	454	456	456	-7
D	9	80	195	212	217	196	180	184	200	209	214	216	-7
D	9	85	841	922	967	865	762	744	809	865	899	910	-8
D	9	90	361	403	417	361	302	282	300	329	346	352	-8
D	9	95	153	169	174	147	122	111	113	123	129	131	-8
D	9	100	644	721	741	633	526	464	459	479	491	495	-9
D	9	105	279	318	332	280	233	202	196	197	198	198	-9
D	9	110	131	151	154	127	104	88	83	80	78	78	-9
D	10	25	398	394	391	395	400	402	395	382	374	372	-4
D	10	30	178	178	179	181	182	184	180	175	172	171	-4
D	10	35	829	832	839	843	845	836	827	810	800	796	-5
D	10	40	406	405	404	408	402	393	390	378	371	368	-5
D	10	45	208	206	204	202	199	193	189	183	179	178	-5
D	10	50	112	110	108	106	104	101	97	93	91	90	-5
D	10	55	623	611	598	584	574	550	529	505	491	486	-6
D	10	60	352	341	329	321	313	297	282	271	264	262	-6
D	10	65	189	184	177	167	164	155	149	142	138	136	-6
D	10	70	958	945	928	873	808	754	745	719	703	698	-7
D	10	75	440	448	455	418	372	349	358	345	337	335	-7
D	10	80	193	202	211	192	167	155	164	157	153	151	-7
D	10	85	826	883	928	842	722	669	714	706	701	700	-8

D	10	90	368	396	409	361	303	277	298	302	304	305	-8
D	10	95	159	169	170	147	128	119	128	130	131	132	-8
D	10	100	673	719	731	631	534	502	546	553	557	559	-9
D	10	105	292	310	322	276	237	220	239	241	242	243	-9
D	10	110	126	142	150	132	110	100	104	101	99	99	-9
D	11	25	396	394	389	391	391	392	393	387	383	382	-4
D	11	30	178	177	177	178	178	179	178	173	170	169	-4
D	11	35	829	831	828	823	816	815	805	792	784	782	-5
D	11	40	411	406	399	389	382	372	367	361	357	356	-5
D	11	45	212	208	201	194	185	178	173	169	167	166	-5
D	11	50	113	111	107	102	96	90	85	84	83	83	-5
D	11	55	621	609	585	560	522	473	451	453	454	455	-6
D	11	60	350	343	329	309	286	253	239	241	242	243	-6
D	11	65	193	188	179	165	149	132	124	127	129	129	-6
D	11	70	984	960	926	846	749	634	625	627	628	629	-7
D	11	75	444	439	436	401	354	313	303	299	297	296	-7
D	11	80	191	192	197	183	160	144	144	137	133	131	-7
D	11	85	838	849	861	796	703	654	655	633	620	615	-8
D	11	90	384	390	386	345	304	283	294	288	284	283	-8
D	11	95	163	162	156	141	128	124	131	132	133	133	-8
D	11	100	663	668	651	593	555	559	606	602	600	599	-9
D	11	105	262	270	272	260	252	259	282	281	280	280	-9
D	11	110	111	116	125	123	119	121	129	125	123	122	-9
D	12	25	397	390	385	384	384	380	390	399	404	406	-4
D	12	30	177	175	177	172	172	177	178	176	175	174	-4
D	12	35	828	821	809	801	789	811	805	776	759	753	-5
D	12	40	411	405	392	381	369	372	362	348	340	337	-5
D	12	45	210	207	196	191	180	176	166	158	153	152	-5
D	12	50	111	109	105	101	95	87	80	76	74	73	-5
D	12	55	606	598	576	555	510	458	418	400	389	386	-6
D	12	60	339	332	321	305	279	242	218	214	212	211	-6
D	12	65	187	185	175	164	146	126	113	111	110	109	-6
D	12	70	980	951	918	859	749	642	575	555	543	539	-7
D	12	75	447	435	422	409	361	318	287	269	258	255	-7
D	12	80	193	189	189	184	169	150	138	125	117	115	-7
D	12	85	851	831	808	794	749	691	634	574	538	526	-8
D	12	90	384	378	366	347	327	302	286	260	244	239	-8
D	12	95	160	156	149	145	141	136	131	120	113	111	-8
D	12	100	636	617	605	609	627	633	619	563	529	518	-9
D	12	105	252	244	239	256	281	305	302	272	254	248	-9
D	12	110	106	103	106	114	126	137	137	124	116	114	-9
D	13	25	398	396	392	390	391	392	393	394	396	397	-4
D	13	30	178	178	178	178	179	180	181	180	179	178	-4
D	13	35	828	830	831	831	829	834	838	831	820	816	-5
D	13	40	406	406	403	399	395	396	396	389	387	386	-5
D	13	45	208	207	203	200	197	197	194	188	187	187	-5
D	13	50	110	110	108	106	104	100	100	96	94	94	-5
D	13	55	604	603	597	581	571	559	541	515	514	514	-6
D	13	60	339	336	331	320	314	305	294	281	283	284	-6
D	13	65	186	184	179	172	167	162	157	150	151	151	-6
D	13	70	956	946	921	878	846	824	803	768	776	779	-7
D	13	75	446	445	439	420	404	399	395	377	357	350	-7
D	13	80	195	197	198	191	185	184	185	175	150	142	-7
D	13	85	848	858	868	835	802	802	810	767	711	693	-8

D	13	90	373	377	378	356	333	326	329	311	288	281	-8
D	13	95	158	159	157	145	133	128	129	122	113	110	-8
D	13	100	649	652	648	600	551	528	523	491	453	440	-9
D	13	105	269	271	272	253	239	229	227	210	193	187	-9
D	13	110	118	119	120	114	107	103	103	96	89	86	-9
T	1	25	218	219	217	219	219	220	215	207	204	203	0
T	1	30	231	232	230	229	225	222	216	208	205	204	0
T	1	35	247	246	243	238	233	226	218	213	209	208	0
T	1	40	258	257	258	256	243	238	229	222	214	211	0
T	1	45	265	266	269	268	263	251	242	236	223	219	0
T	1	50	271	272	274	272	269	259	254	250	249	249	0
T	1	55	270	269	268	264	261	257	254	252	254	255	0
T	1	60	257	254	252	251	249	249	248	244	244	244	0
T	1	65	234	232	233	234	237	238	239	232	228	227	0
T	1	70	211	211	211	216	222	229	229	222	200	190	0
T	1	75	200	201	201	204	212	219	220	214	194	187	0
T	1	80	197	198	196	198	204	211	213	211	211	211	0
T	1	85	193	194	192	194	200	207	211	211	211	211	0
T	1	90	185	185	186	189	199	208	214	214	214	214	0
T	1	95	187	187	190	195	203	210	214	216	217	218	0
T	1	100	204	203	204	204	206	210	214	215	216	216	0
T	1	105	231	232	228	222	217	215	217	215	214	213	0
T	1	110	273	276	271	259	248	240	235	229	225	224	0
T	2	25	218	218	218	219	218	217	217	214	200	195	0
T	2	30	231	232	231	228	224	219	220	217	200	194	0
T	2	35	246	245	244	239	234	228	224	221	199	192	0
T	2	40	258	259	258	254	250	243	234	227	205	198	0
T	2	45	268	270	271	268	265	257	247	237	219	213	0
T	2	50	273	275	275	271	269	263	256	247	250	251	0
T	2	55	270	268	266	264	261	259	254	249	248	248	0
T	2	60	253	250	247	247	247	247	245	240	234	232	0
T	2	65	233	228	228	230	234	237	235	228	212	207	0
T	2	70	213	210	213	217	221	226	226	217	195	188	0
T	2	75	201	201	205	209	213	217	218	211	193	187	0
T	2	80	195	195	199	201	205	211	213	207	210	211	0
T	2	85	193	192	192	195	200	205	209	208	207	207	0
T	2	90	193	191	189	190	195	202	207	208	209	209	0
T	2	95	200	197	197	197	197	200	206	209	211	211	0
T	2	100	219	215	213	210	207	206	210	214	216	217	0
T	2	105	251	246	237	230	225	225	228	230	231	232	0
T	2	110	296	290	278	266	258	259	261	261	261	261	0
T	3	25	219	221	219	220	219	217	218	221	198	190	0
T	3	30	231	232	231	230	224	221	222	226	210	205	0
T	3	35	245	247	245	240	236	232	231	231	226	224	0
T	3	40	260	261	259	254	251	248	243	237	245	248	0
T	3	45	271	272	271	266	264	262	255	247	254	256	0
T	3	50	275	274	273	269	268	267	261	255	269	274	0
T	3	55	268	266	263	261	261	260	257	253	254	254	0
T	3	60	250	245	243	245	246	248	245	241	232	229	0
T	3	65	229	225	226	230	234	236	234	228	211	205	0
T	3	70	213	209	213	219	223	225	226	218	198	191	0
T	3	75	202	201	206	210	213	217	219	211	194	188	0
T	3	80	197	196	200	202	203	206	211	207	212	214	0
T	3	85	197	195	195	195	196	199	202	200	199	198	0

T	3	90	198	193	190	189	191	192	196	199	201	201	0
T	3	95	204	199	195	195	196	197	199	205	209	210	0
T	3	100	220	214	210	208	207	209	215	223	228	229	0
T	3	105	255	245	236	227	226	231	245	256	263	265	0
T	3	110	306	291	275	265	263	274	291	303	310	313	0
T	4	25	220	221	222	222	222	222	223	221	211	208	0
T	4	30	233	233	235	232	229	229	228	222	222	222	0
T	4	35	248	249	247	244	242	243	237	229	239	242	0
T	4	40	262	262	260	256	256	258	252	243	255	259	0
T	4	45	273	272	271	269	269	270	266	259	275	280	0
T	4	50	275	274	273	271	272	272	271	267	281	286	0
T	4	55	267	265	264	263	263	265	262	261	264	265	0
T	4	60	248	246	246	247	249	249	249	247	244	243	0
T	4	65	227	227	231	235	236	237	237	234	227	225	0
T	4	70	209	210	218	222	224	225	226	224	209	204	0
T	4	75	200	200	206	212	213	214	215	213	202	198	0
T	4	80	199	199	201	203	201	199	202	200	207	209	0
T	4	85	202	200	199	197	191	186	187	187	187	187	0
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T	4	95	199	193	190	189	191	191	193	197	199	200	0
T	4	100	209	201	195	196	201	210	221	232	239	241	0
T	4	105	239	229	220	216	218	237	263	285	298	303	0
T	4	110	293	278	264	256	262	284	317	344	360	366	0
T	5	25	221	221	223	223	224	225	225	223	238	243	0
T	5	30	234	233	235	233	231	232	232	231	248	254	0
T	5	35	250	250	248	245	246	248	246	238	254	259	0
T	5	40	262	262	260	259	262	264	261	255	264	267	0
T	5	45	270	271	271	271	273	277	275	270	270	270	0
T	5	50	274	274	275	275	276	278	278	278	279	279	0
T	5	55	269	267	265	265	267	268	270	271	273	274	0
T	5	60	252	252	251	252	251	253	254	257	262	264	0
T	5	65	227	231	236	237	237	237	238	241	242	242	0
T	5	70	206	211	218	220	220	221	224	229	223	221	0
T	5	75	199	200	203	204	204	205	209	211	207	206	0
T	5	80	202	199	197	194	190	186	188	188	196	199	0
T	5	85	203	198	196	189	179	170	168	168	168	168	0
T	5	90	193	194	192	185	172	161	159	162	164	164	0
T	5	95	187	187	187	187	184	180	180	184	186	187	0
T	5	100	193	191	194	197	204	212	223	234	241	243	0
T	5	105	219	215	216	220	230	253	279	302	316	320	0
T	5	110	269	259	255	259	274	304	343	373	391	397	0
T	6	25	220	220	223	225	225	225	228	229	239	242	0
T	6	30	234	234	234	234	233	234	238	239	246	248	0
T	6	35	249	249	246	246	247	250	251	249	258	261	0
T	6	40	259	260	259	259	262	266	266	264	269	271	0
T	6	45	268	269	270	272	275	277	279	278	281	282	0
T	6	50	272	273	275	275	276	279	282	283	286	287	0
T	6	55	269	268	267	267	269	273	275	278	280	281	0
T	6	60	255	256	253	252	252	256	259	264	267	268	0
T	6	65	232	234	233	232	232	236	240	245	247	248	0
T	6	70	208	211	213	213	212	214	220	225	220	218	0
T	6	75	199	199	201	198	195	195	199	201	204	205	0
T	6	80	201	196	194	190	181	175	173	173	185	189	0
T	6	85	199	195	192	184	170	156	151	149	148	147	0

T	6	90	189	189	188	179	162	147	144	145	146	146	0
T	6	95	184	186	189	189	182	173	171	173	174	175	0
T	6	100	191	193	198	206	213	219	222	226	229	229	0
T	6	105	215	214	221	232	247	265	282	295	303	305	0
T	6	110	261	253	253	264	285	313	343	366	380	384	0
T	7	25	218	220	222	224	224	227	230	231	239	242	0
T	7	30	231	233	233	232	235	238	239	238	248	251	0
T	7	35	247	245	244	244	246	250	252	251	259	262	0
T	7	40	258	256	256	257	259	264	267	266	269	270	0
T	7	45	265	265	268	268	271	274	278	279	283	284	0
T	7	50	271	271	273	272	274	276	281	285	293	296	0
T	7	55	270	269	267	266	267	270	276	281	283	284	0
T	7	60	257	257	253	250	251	256	262	267	267	267	0
T	7	65	234	234	230	226	229	234	241	246	244	243	0
T	7	70	211	211	209	207	207	211	217	222	214	211	0
T	7	75	200	200	200	197	191	189	191	194	196	197	0
T	7	80	197	196	195	189	178	168	165	164	182	188	0
T	7	85	193	194	191	183	167	153	144	140	138	137	0
T	7	90	185	186	186	179	167	153	145	141	139	138	0
T	7	95	187	189	193	195	192	184	174	168	164	163	0
T	7	100	204	204	206	214	222	221	216	212	210	209	0
T	7	105	231	229	229	237	246	255	258	260	261	262	0
T	7	110	273	265	260	265	276	293	306	314	319	320	0
T	8	25	218	219	221	223	225	229	229	227	239	243	0
T	8	30	231	233	230	232	234	238	237	234	247	251	0
T	8	35	246	244	243	242	246	249	249	245	259	264	0
T	8	40	258	255	253	254	259	261	262	260	270	273	0
T	8	45	268	265	267	267	269	271	274	274	285	289	0
T	8	50	273	272	271	271	271	274	277	279	289	292	0
T	8	55	270	268	266	264	263	266	272	275	276	276	0
T	8	60	253	257	254	250	248	250	257	263	260	259	0
T	8	65	233	236	235	230	225	229	237	245	240	238	0
T	8	70	213	218	217	212	208	210	215	221	212	209	0
T	8	75	201	205	207	203	196	191	190	194	197	198	0
T	8	80	195	199	201	196	183	172	165	167	192	200	0
T	8	85	193	196	196	189	174	161	151	148	146	146	0
T	8	90	193	194	191	187	180	170	159	150	145	143	0
T	8	95	200	199	197	197	199	194	181	170	163	161	0
T	8	100	219	216	211	208	212	211	203	193	187	185	0
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T	8	110	296	291	276	263	256	254	250	241	236	234	0
T	9	25	219	220	222	224	225	225	226	224	229	231	0
T	9	30	231	232	233	231	233	234	233	229	237	240	0
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T	9	45	271	269	268	265	267	265	268	266	272	274	0
T	9	50	275	273	272	270	270	271	271	272	278	280	0
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T	9	60	250	254	257	250	241	242	250	256	245	241	0
T	9	65	229	238	242	234	224	223	232	240	229	225	0
T	9	70	213	221	225	218	209	207	214	220	204	199	0
T	9	75	202	208	211	206	198	194	195	201	191	188	0
T	9	80	197	200	202	198	190	182	180	184	211	220	0
T	9	85	197	199	198	192	185	177	172	173	174	174	0

T	9	90	198	199	197	193	191	185	177	173	171	170	0
T	9	95	204	207	206	205	203	196	188	179	174	172	0
T	9	100	220	225	222	216	211	204	195	184	177	175	0
T	9	105	255	257	248	236	226	216	202	187	178	175	0
T	9	110	306	307	294	278	261	244	223	198	183	178	0
T	10	25	220	221	223	223	221	220	220	221	213	210	0
T	10	30	233	233	232	230	228	224	225	225	216	213	0
T	10	35	248	246	243	241	238	235	234	232	225	223	0
T	10	40	262	260	257	252	251	249	245	244	237	235	0
T	10	45	273	271	269	265	263	261	259	257	253	252	0
T	10	50	275	274	273	271	269	265	265	265	261	260	0
T	10	55	267	267	266	262	258	255	256	258	250	247	0
T	10	60	248	251	254	247	241	240	246	246	231	226	0
T	10	65	227	233	240	236	224	222	231	233	214	208	0
T	10	70	209	216	223	219	210	210	218	219	198	191	0
T	10	75	200	206	210	207	203	202	207	209	200	197	0
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T	10	85	202	203	200	195	194	193	194	197	199	199	0
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T	10	100	209	217	222	221	217	209	210	193	183	179	0
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T	11	25	221	221	222	220	219	210	216	215	201	196	0
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T	11	40	262	260	257	253	246	209	205	205	224	220	0
T	11	45	270	270	269	266	261	252	248	251	209	205	0
T	11	50	274	274	273	271	266	258	250	260	250	250	0
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T	11	60	252	252	253	249	244	240	245	244	206	200	0
T	11	65	227	229	234	233	229	230	235	231	226	224	0
T	11	70	206	209	215	216	216	220	225	220	210	207	0
T	11	75	199	202	205	206	206	212	218	215	196	190	0
T	11	80	202	203	201	199	201	207	211	214	222	225	0
T	11	85	203	203	199	196	199	203	209	213	215	216	0
T	11	90	193	192	191	194	200	207	211	212	213	210	0
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T	11	110	269	282	286	294	272	253	231	212	201	197	0
T	12	25	220	221	222	219	217	221	216	210	206	205	0
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T	12	40	259	258	257	255	248	236	228	227	220	218	0
T	12	45	268	267	270	268	263	248	242	243	234	231	0
T	12	50	272	272	273	271	266	257	254	258	255	254	0
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T	12	60	255	255	254	252	249	247	247	245	247	248	0
T	12	65	232	230	233	236	235	238	240	233	238	240	0
T	12	70	208	208	211	216	222	228	201	224	206	200	0
T	12	75	199	200	202	204	212	218	222	217	198	192	0
T	12	80	201	201	198	198	204	211	214	214	219	221	0
T	12	85	199	200	198	197	201	207	213	214	215	215	0

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T    12    90   189   188   189   194   203   213   217   217   217   217     0
T    12    95   184   184   187   196   207   219   222   219   217   217     0
T    12   100   191   193   197   204   212   220   221   217   215   214     0
T    12   105   215   220   225   225   222   219   215   211   209   208     0
T    12   110   261   270   271   263   250   238   227   216   209   207     0
T    13    25   219   220   221   222   221   222   222   220   218   217     0
T    13    30   232   233   232   231   229   228   227   275   224   224     0
T    13    35   247   247   244   241   240   238   236   233   234   234     0
T    13    40   260   259   257   255   254   252   248   244   244   244     0
T    13    45   269   269   269   268   267   264   261   258   257   257     0
T    13    50   273   273   273   272   270   268   267   267   270   271     0
T    13    55   269   268   266   264   262   262   262   263   263   263     0
T    13    60   252   252   251   249   247   248   251   251   247   246     0
T    13    65   230   231   233   233   231   233   237   236   230   228     0
T    13    70   210   212   215   216   216   219   223   222   207   203     0
T    13    75   200   202   205   205   205   206   209   208   198   194     0
T    13    80   198   199   199   197   195   194   194   194   206   210     0
T    13    85   198   197   196   192   188   185   184   184   184   184     0
T    13    90   193   192   191   189   187   185   184   183   183   183     0
T    13    95   193   193   194   196   197   197   195   194   193   193     0
T    13   100   206   206   207   209   211   213   214   213   212   212     0
T    13   105   235   234   232   230   230   233   236   238   239   239     0
T    13   110   283   280   273   268   265   268   271   271   271   271     0

***STATIONARY PERTURBATIONS, CODE S***
S     1    30    10    -1    -6   -48   -93     0     2     0   -21   -33     0    -1    -7   -24   -59     0
S     1    30    40    -1    -6   -57  -104     0    -3    -6   -15   -46     0    -1    -3   -42   -59     0
S     1    30    70   -10   -15   -66   -82     0   -25   -17   -26   -46     0    20     2   -38   -36     0
S     1    30   100   -10   -23    -3     5     0    -9   -11    14     7     0     3   -11   -20    -2     0
S     1    30   130    -1    11    51   104     0     2    17    48    73     0    -6    -3     3    36     0
S     1    30   160    -1    11    96   191     0     8    11    72   126     0   -10    -3    21    59     0
S     1    30   190    15    28    87   169     0    19    22    43    86     0    -1     6    43    78     0
S     1    30   220     7    19    69    93     0     8    17    14    33     0    -6     2    52    64     0
S     1    30   250   -10    -6     6     5     0    -9   -11   -26   -20     0     3    11    38    26     0
S     1    30   280    15    11   -39   -82     0     2     0   -38   -66     0     7     6     3   -12     0
S     1    30   310    -1    -6   -48  -104     0     2   -11   -38   -66     0    -1     2   -11   -40     0
S     1    30   340    -1   -15   -48  -104     0     2   -11   -26   -46     0    -6    -3   -24   -55     0
S     1    40    10    14    18   -43   -89     0     9    -1   -63   -66     0     5    23    20   -23     0
S     1    40    40    28    29   -35   -84     0    22     7   -57   -69     0     5    19    20   -15     0
S     1    40    70    21    25   -70   -93     0    17     4  -102   -96     0     5    19    32     2     0
S     1    40   100     3   -28   -98   -74     0     9   -35  -110   -82     0    -7     7    12    10     0
S     1    40   130   -21   -43   -31     8     0   -20   -27    -5    -6     0     1   -16   -29    15     0
S     1    40   160   -18    -3   102   125     0    -7    33   138   125     0   -11   -36   -33     2     0
S     1    40   190   -32    18   173   202     0   -22    48   207   195     0    -7   -28   -29     6     0
S     1    40   220   -21    11   130   168     0   -15    25   124   138     0    -7   -12     4    27     0
S     1    40   250   -11   -21    43    62     0   -15   -22    23    34     0     1    -1    20    27     0
S     1    40   280     0    -3   -11   -35     0    -9     1   -11   -32     0     8    -5     0    -2     0
S     1    40   310    24     0   -70   -88     0    25    -7   -52   -66     0     1     7   -21   -23     0
S     1    40   340    14    -3   -90  -103     0     6   -25   -93   -76     0     8    23     4   -27     0
S     1    52    10    22    40   -29  -102     0    13    38   -18   -97     0     9     0   -11    -5     0
S     1    52    40    30    68    13   -80     0    20    60     9   -99     0     9     7     5    19     0
S     1    52    70    27    65    21   -52     0    17    62   -14   -86     0     9     7    36    35     0
S     1    52   100    15     4   -31   -32     0    17    -3   -60   -55     0    -2     7    32    23     0
S     1    52   130   -14   -38   -19    26     0    -5   -41   -26    19     0    -9     0     9     7     0
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S	1	52	160	-24	-28	74	125	0	-15	-30	80	138	0	-9	3	-7	-12	0
S	1	57	190	-22	-13	96	183	0	-16	-13	104	195	0	-6	0	-7	-9	0
S	1	52	220	-27	-35	90	165	0	-20	-37	85	166	0	-6	3	5	-1	0
S	1	52	250	-24	-33	54	62	0	-18	-31	52	70	0	-6	0	1	-9	0
S	1	52	280	-9	-18	-13	-52	0	-6	-10	3	-42	0	-2	-8	-15	-12	0
S	1	52	310	7	-16	-105	-115	0	5	-4	-82	-99	0	2	-12	-26	-16	0
S	1	52	340	19	1	-151	-128	0	9	8	-133	-110	0	9	-8	-22	-20	0
S	1	60	10	28	26	-59	-120	0	25	53	-14	-91	0	6	-22	-41	-27	0
S	1	60	40	37	65	-6	-75	0	32	77	36	-65	0	6	-10	-37	-10	0
S	1	60	70	42	70	35	-29	0	22	77	48	-35	0	18	-6	-12	11	0
S	1	60	100	19	12	-6	-14	0	12	5	-22	-24	0	6	6	12	15	0
S	1	60	130	-27	-32	6	39	0	-12	-44	-30	22	0	-14	10	37	19	0
S	1	60	160	-32	-13	76	130	0	-25	-40	60	104	0	-10	30	21	28	0
S	1	60	190	-27	2	106	206	0	-25	-27	81	155	0	-2	26	21	41	0
S	1	60	220	-32	-27	118	176	0	-28	-40	68	155	0	-6	14	49	24	0
S	1	60	250	-27	-27	65	47	0	-25	-37	48	63	0	-6	10	16	-15	0
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S	1	90	130	-77	[illegible]	41	116	0	-56	-51	3	95	0	-21	12	37	23	0
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S	10	84	160	15	14	-21	-17	0	11	15	-10	-12	0	8	2	-11	-11	0
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S	10	84	220	10	-6	-13	-24	0	11	-6	-10	-12	0	-2	-3	-1	-11	0
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S	10	80	340	-22	-39	-19	-6	0	-18	-37	-23	-12	0	-7	-3	4	9	0
S	10	90	10	-13	14	42	42	0	-8	12	37	36	0	-5	-2	0	3	0
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S	12	76	40	25	34	-38	-97	0	18	25	-41	-89	0	7	10	2	-12	0
S	12	76	70	46	61	-26	-80	0	45	53	-21	-68	0	2	10	-3	-12	0
S	12	76	100	15	29	-2	32	0	18	22	6	49	0	-3	5	-8	-17	0
S	12	76	130	15	18	23	84	0	12	19	33	97	0	2	0	-8	-12	0
S	12	76	160	10	13	11	127	0	3	10	21	113	0	2	0	-8	11	0
S	12	76	190	-11	-25	54	213	0	-12	-18	60	183	0	2	-5	-8	20	0
S	12	76	220	-1	-25	23	75	0	-6	-18	33	39	0	2	-10	-12	30	0
S	12	76	250	-16	-57	-14	-45	0	-18	-58	-10	-41	0	2	0	-3	2	0
S	12	76	280	-11	-14	-44	-45	0	-9	-8	-52	-41	0	2	-5	6	2	0
S	12	76	310	-16	-30	35	-80	0	-9	-24	14	-79	0	-8	-10	20	-3	0
S	12	76	340	-27	-14	-8	-80	0	-21	-8	-21	-73	0	-3	-5	15	-3	0
S	12	84	10	-34	14	-5	-114	0	-24	16	-14	-105	0	-10	-1	8	-9	0
S	12	84	40	32	45	-41	-114	0	26	41	-38	-96	0	6	4	-1	-19	0
S	12	84	70	56	70	-31	-99	0	45	66	-26	-81	0	11	4	-6	-19	0
S	12	84	100	22	37	-1	11	0	11	27	-5	26	0	11	9	4	-14	0
S	12	84	130	20	21	24	72	0	14	17	18	77	0	6	4	8	-4	0
S	12	84	160	14	12	1	136	0	8	13	11	129	0	6	-1	-11	6	0
S	12	84	190	-10	-27	39	234	0	-10	-26	56	216	0	0	-1	-15	15	0
S	12	84	220	-4	-40	-3	100	0	0	-29	27	87	0	-5	-11	-30	10	0
S	12	84	250	-20	-62	-26	-41	0	-15	-57	-12	-45	0	-5	-6	-15	6	0
S	12	84	280	-14	-15	-37	-35	0	-9	-13	-46	-48	0	-5	-1	8	15	0
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S	12	84	340	-38	-19	14	-75	0	-28	-18	-4	-76	0	-10	-1	18	1	0
S	12	90	10	-49	10	-9	-129	0	-31	19	6	-107	0	-21	-9	-12	-24	0
S	12	90	40	37	45	-52	-137	0	32	51	-27	-107	0	6	-4	-22	-28	0
S	12	90	70	72	74	-41	-121	0	53	73	-24	-92	0	18	1	-22	-24	0
S	12	90	100	32	39	8	7	0	20	42	-4	-1	0	12	1	11	10	0
S	12	90	130	26	22	35	79	0	23	22	22	61	0	1	1	11	15	0
S	12	90	160	14	10	-9	142	0	17	13	2	133	0	1	-4	-12	10	0
S	12	90	190	-9	-25	35	270	0	-10	-29	29	215	0	1	1	6	43	0
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S	12	90	250	-26	-66	-30	-33	0	-19	-67	-37	-40	0	-5	1	6	5	0
S	12	90	280	-14	-13	-36	-25	0	-16	-16	-34	-30	0	1	1	2	10	0
S	12	90	310	-26	-31	100	-73	0	-28	-45	59	-68	0	1	12	39	-4	0
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S	13	30	10	1	-4	-15	-24	0	2	-4	-7	-5	0	0	0	-8	-19	0
S	13	30	40	0	-2	-16	-28	0	0	-2	-4	-9	0	0	0	-11	-17	0
S	13	30	70	0	-2	-16	-21	0	-5	-3	-9	-15	0	4	2	-7	-7	0
S	13	30	100	1	-7	-5	2	0	2	-6	-1	1	0	1	0	-4	1	0
S	13	30	130	0	-1	9	34	0	0	0	11	25	0	0	0	0	8	0
S	13	30	160	-1	0	25	53	0	0	0	22	38	0	0	1	4	14	0
S	13	30	190	3	5	28	53	0	1	2	18	25	0	1	2	11	24	0
S	13	30	220	-3	4	28	30	0	-4	4	11	10	0	0	1	17	22	0
S	13	30	250	-3	4	5	-1	0	-3	4	-9	-10	0	0	0	16	10	0
S	13	30	280	10	12	-9	-27	0	8	11	-9	-24	0	3	2	1	0	0
S	13	30	310	-3	2	-11	-32	0	0	4	-7	-19	0	-2	-1	-3	-11	0

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S	13	40	40	3	9	-10	-33	0	0	1	-15	-27	0	3	7	4	-5	0
S	13	40	70	3	8	-14	-23	0	3	3	-19	-18	0	1	5	4	-3	0
S	13	40	100	0	-3	-15	-5	0	0	-2	-10	-1	0	0	0	-4	-2	0
S	13	40	130	-4	-6	4	27	0	-4	0	14	27	0	0	-5	-9	0	0
S	13	40	160	-3	0	31	55	0	0	7	42	53	0	-1	-6	-8	2	0
S	13	40	190	-6	3	44	61	0	-5	10	48	55	0	0	-6	-3	6	0
S	13	40	220	-3	3	38	44	0	-1	7	36	32	0	-1	-3	1	12	0
S	13	40	250	-1	-3	11	13	0	0	-3	4	4	0	-1	0	7	8	0
S	13	40	280	4	-4	-15	-17	0	3	-2	-20	-21	0	1	-1	5	4	0
S	13	40	310	6	-4	-29	-36	0	7	-5	-30	-35	0	0	1	2	0	0
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S	13	52	160	-4	-4	21	50	0	-2	-1	26	53	0	-1	-2	-3	-1	0
S	13	52	190	-3	-4	26	56	0	-1	-4	29	57	0	0	0	-2	0	0
S	13	52	220	-7	-12	18	40	0	-5	-11	19	40	0	0	0	0	1	0
S	13	52	250	-10	-18	0	7	0	-9	-17	-1	5	0	-1	0	1	2	0
S	13	52	280	-10	-15	-19	-21	0	-10	-15	-20	-23	0	0	0	1	2	0
S	13	52	310	-4	-15	-26	-36	0	-3	-16	-27	-38	0	0	1	2	2	0
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S	13	60	250	-12	-18	6	9	0	-11	-18	-4	7	0	-1	1	11	1	0
S	13	60	280	-10	-16	-19	-22	0	-10	-15	-17	-19	0	0	0	0	-2	0
S	13	60	310	-5	-16	-25	-38	0	-3	-13	-24	-32	0	-2	-1	-1	-6	0
S	13	60	340	7	-1	-28	-46	0	6	2	-20	-37	0	0	-4	-8	-8	0
S	13	68	10	7	16	-9	-54	0	8	17	-3	-39	0	0	0	-6	-14	0
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S	13	68	70	19	27	-4	-25	0	15	27	1	-19	0	4	1	-4	-5	0
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S	13	68	250	-13	-19	19	12	0	-14	-17	8	6	0	0	0	12	7	0
S	13	68	280	-9	-14	-19	-25	0	-12	-15	-17	-23	0	3	1	1	0	0
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S	13	68	340	7	-5	-36	-58	0	9	-4	-27	-45	0	0	-1	-7	-14	0
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S	13	76	40	21	30	-14	-54	0	17	23	-17	-50	0	4	8	3	-4	0
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S	13	76	130	-6	-12	1	40	0	-4	-5	9	42	0	0	-5	-7	0	0

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S     13    76   160   -10    -7    19    67     0    -7     0    28    66     0    -2    -6    -8     0     0
S     13    76   190    -5     0    33    94     0    -3     6    38    90     0    -1    -4    -4     4     0
S     13    76   220    -7   -11    49    73     0    -6    -7    48    62     0    -1    -2     0     8     0
S     13    76   250   -16   -18    30    21     0   -13   -18    23    14     0    -1     0     6     7     0
S     13    76   280    -6   -14   -17   -23     0    -8   -13   -21   -26     0     2     0     4     4     0
S     13    76   310   -11   -17   -28   -52     0   -10   -18   -30   -51     0     0     1     2     1     0
S     13    76   340     7    -3   -40   -70     0     5    -7   -42   -65     0     2     5     3    -4     0
S     13    84    10    12    28    -8   -71     0    10    24    -9   -70     0     2     3     1    -1     0
S     13    84    40    26    39   -12   -58     0    23    36   -11   -55     0     4     4     0     0     0
S     13    84    70    28    34    -4   -33     0    23    32    -5   -32     0     4     1     1     0     0
S     13    84   100     7     5   -11     4     0     7     5   -12     5     0     0     0     1     0     0
S     13    84   130    -9   -19    -5    39     0    -6   -13    -4    39     0    -2    -3     0     0     0
S     13    84   160   -14   -14     9    64     0   -10   -11    15    67     0    -2    -3    -5    -2     0
S     13    84   190    -7    -3    27    95     0    -4    -3    32    97     0    -1     0    -3    -1     0
S     13    84   220   -10   -13    49    79     0   -10   -12    50    78     0    -1     0     0     1     0
S     13    84   250   -18   -19    36    26     0   -16   -18    33    23     0    -1     0     2     3     0
S     13    84   280    -6   -15   -12   -19     0    -7   -15   -13   -21     0     0     0     2     3     0
S     13    84   310   -11   -16   -25   -48     0    -9   -17   -28   -51     0     0     1     3     4     0
S     13    84   340     8     0   -36   -73     0     6    -1   -39   -72     0     1     2     1    -1     0
S     13    90    10    11    29   -11   -74     0    15    31    -4   -67     0    -3    -3    -6    -6     0
S     13    90    40    30    40   -17   -61     0    27    42    -7   -55     0     2    -1   -10    -6     0
S     13    90    70    32    36    -6   -35     0    27    36    -1   -32     0     5     0    -3    -2     0
S     13    90   100     9     4   -10     4     0     5     4   -11     2     0     4     1     1     4     0
S     13    90   130   -11   -20    -3    41     0    -9   -22    -8    35     0    -2     1     5     6     0
S     13    90   160   -16   -15     7    62     0   -15   -16     6    59     0     0     0     1     4     0
S     13    90   190    -8     0    24   100     0    -7    -6    24    89     0     0     6     1    10     0
S     13    90   220   -11   -13    55    82     0   -11   -15    42    76     0     1     3    12     5     0
S     13    90   250   -20   -20    42    30     0   -18   -20    31    27     0     0     0    12     3     0
S     13    90   280    -5   -15   -12   -18     0    -5   -15   -10   -15     0     0     0     0     0     0
S     13    90   310   -13   -16   -24   -48     0   -11   -15   -23   -43     0    -2     0    -1    -4     0
S     13    90   340     9    -1   -39   -78     0     8     3   -32   -70     0     1    -4    -7    -7     0

----- END OF FILE WRITTEN -----

***RANDOM PERTURBATIONS,  CODE R***
R      1    25    11    21    40    77    85    14    18    40    53    55    13    18    28    46    51
R      1    30    18    28    47    98   110    14    29    49    91   101    18    23    32    41    44
R      1    35    28    36    56   112   125    24    34    55   103   117    20    27    42    57    61
R      1    40    33    46    77   134   149    31    39    61   114   128    18    29    61    64    65
R      1    45    36    54   103   161   177    38    51    84   136   151    20    26    55    58    59
R      1    50    40    60   119   183   201    40    57   108   164   181    21    23    42    47    47
R      1    55    44    65   125   189   207    42    61   133   200   219    18    29    43    46    46
R      1    60    48    72   123   179   194    46    72   130   198   217    23    34    39    51    54
R      1    65    55    74   115   166   180    51    86   134   191   205    34    39    44    52    54
R      1    70    67    75   106   150   162    66    89   131   185   199    44    46    50    55    57
R      1    75    74    74    95   123   131    86    93   123   171   177    52    69    76    73    72
R      1    80    92    93   102    99    99    81    92   117   150   160    52    60    76    96   101
R      1    85   110   114   115    93    84   102    95   112   131   137    65    70    69    83    86
R      1    90   146   134   119    83    62   130   167   162   116    96   106   108   110   104   101
R      1   100   132   132   132   132   132   154   154   154   154   154    75    75    75    75    75
R      1   120   183   183   183   183   183    79    79    79    79    79   211   211   211   211   211
R      1   140   125   125   125   125   125    72    72    72    72    72   146   146   146   146   146
R      1   160    90    90    90    90    90    65    65    65    65    65   105   105   105   105   105
R      1   180    71    71    71    71    71    58    58    58    58    58    81    81    81    81    81
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R	1	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	59
R	2	25	13	19	35	37	35	18	21	26	28	27	14	16	35	41	42
R	2	30	19	24	52	64	67	12	23	40	59	64	17	22	33	58	62
R	2	35	29	32	68	81	82	24	31	53	83	92	22	26	36	58	62
R	2	40	35	41	84	99	101	33	36	70	85	91	21	28	39	62	66
R	2	45	40	50	98	122	127	39	42	99	106	110	21	27	40	58	63
R	2	50	44	59	106	138	144	42	52	100	136	146	20	24	35	71	80
R	2	55	46	67	112	152	159	47	60	113	164	176	16	30	42	95	109
R	2	60	51	75	117	166	177	49	73	113	171	183	23	34	35	102	120
R	2	65	57	79	117	170	184	53	86	129	182	194	32	37	45	53	56
R	2	70	69	79	112	161	176	68	93	133	188	202	44	45	49	54	55
R	2	75	75	78	103	141	152	86	97	130	181	195	52	67	73	70	69
R	2	80	93	93	106	118	122	81	95	123	166	178	52	61	75	92	97
R	2	95	110	111	114	104	100	103	96	118	147	156	65	70	70	84	88
R	2	90	146	133	118	88	72	130	163	159	127	114	106	111	114	107	105
R	2	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	2	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	2	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	2	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	2	180	71	71	71	71	71	58	58	58	58	58	81	61	81	81	81
R	2	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	3	25	22	27	32	74	82	26	27	44	67	72	14	16	33	38	39
R	3	30	27	34	42	84	94	20	28	36	82	93	16	19	35	44	46
R	3	35	38	42	58	95	105	25	37	46	87	96	22	22	32	47	50
R	3	40	50	50	70	112	124	32	39	66	97	105	25	24	34	46	50
R	3	45	64	64	78	130	145	41	43	66	105	115	34	27	35	43	45
R	3	50	86	79	91	150	165	66	58	77	127	140	27	28	32	38	40
R	3	55	96	93	103	163	177	93	76	88	152	167	20	29	36	37	38
R	3	60	95	101	115	175	189	104	106	99	161	176	25	31	35	43	46
R	3	65	70	94	128	187	203	79	104	126	182	196	24	32	40	46	48
R	3	70	75	92	128	190	207	77	105	141	199	215	39	41	44	48	49
R	3	75	78	89	122	181	198	91	109	146	208	225	49	62	64	61	60
R	3	80	92	92	114	158	170	83	104	139	204	221	52	63	71	81	83
R	3	85	109	105	111	130	135	103	99	130	184	198	66	71	72	85	90
R	3	90	145	129	112	97	91	128	151	153	153	153	108	121	122	116	114
R	3	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	3	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	3	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	3	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	3	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	3	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	4	25	17	20	20	29	32	22	17	16	27	29	14	13	15	23	25
R	4	30	22	26	30	42	47	15	22	18	28	30	15	16	20	26	29
R	4	35	30	33	43	58	64	25	28	29	37	40	18	20	28	27	31
R	4	40	35	40	59	78	86	32	32	40	49	53	17	20	34	37	42
R	4	45	38	48	77	103	113	39	38	52	67	70	19	20	33	46	53
R	4	50	41	57	94	127	138	38	43	71	100	108	19	21	32	40	44
R	4	55	47	68	109	143	155	41	51	88	126	136	16	23	31	30	31
R	4	60	54	81	125	157	161	48	63	105	137	152	24	26	32	34	35
R	4	65	62	96	140	176	190	56	83	126	143	155	30	28	31	48	51
R	4	70	73	101	146	201	219	72	109	150	177	196	43	38	36	44	45
R	4	75	79	100	143	216	233	91	120	164	225	245	49	56	50	48	46
R	4	80	92	90	124	198	215	85	115	157	235	251	53	66	66	63	59
R	4	85	108	94	104	162	178	103	103	146	227	243	66	72	75	86	88

R	4	90	144	122	102	110	118	125	134	143	183	196	110	133	132	126	123
R	4	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	4	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	4	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	4	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	4	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	4	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	5	25	12	16	21	20	21	16	18	17	22	23	15	13	12	20	22
R	5	30	20	21	29	29	30	10	17	19	23	23	17	17	17	24	26
R	5	35	33	30	38	41	43	17	23	29	27	26	22	19	19	24	27
R	5	40	46	38	48	56	59	26	26	35	38	38	24	18	24	30	32
R	5	45	62	48	60	72	77	48	34	42	48	50	26	20	23	31	35
R	5	50	70	59	72	90	97	65	45	55	67	71	28	22	24	31	34
R	5	55	76	68	83	102	110	74	59	67	87	95	26	23	24	24	25
R	5	60	76	77	97	109	120	88	66	79	102	107	25	27	28	24	23
R	5	65	66	87	111	127	134	70	81	101	98	105	26	31	31	39	41
R	5	70	74	90	116	148	155	74	99	120	128	135	40	40	35	36	36
R	5	75	78	91	116	162	172	90	107	131	164	170	48	54	50	41	36
R	5	80	92	92	109	152	163	82	99	126	177	189	52	62	62	53	48
R	5	85	109	105	108	128	134	105	115	133	171	181	65	70	70	73	74
R	5	90	145	128	108	92	87	124	129	140	159	165	107	113	112	108	107
R	5	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	5	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	5	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	5	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	5	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	5	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	6	25	17	20	15	20	22	20	20	14	17	18	14	11	12	12	12
R	6	30	22	24	20	24	26	16	18	14	21	23	16	14	12	18	19
R	6	35	31	30	28	35	37	27	25	17	25	27	20	16	17	22	24
R	6	40	36	36	37	42	45	34	32	28	37	40	18	17	19	22	23
R	6	45	39	41	46	53	56	39	35	34	35	37	18	18	20	22	24
R	6	50	43	48	56	62	65	40	39	41	51	54	20	20	22	17	17
R	6	55	47	55	66	68	70	45	50	54	63	67	19	24	24	15	12
R	6	60	51	63	75	71	71	50	55	66	67	70	26	30	32	17	14
R	6	65	57	75	85	81	81	52	70	82	59	60	31	34	31	29	29
R	6	70	69	79	87	96	96	67	87	93	84	81	43	42	34	27	24
R	6	75	76	84	90	104	106	87	96	100	104	101	49	54	48	33	24
R	6	80	94	94	96	104	105	79	86	97	113	117	52	59	58	42	35
R	6	85	110	113	110	99	95	106	122	124	119	118	65	68	66	58	56
R	6	90	146	131	113	80	68	124	126	138	139	140	104	96	96	93	91
R	6	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	6	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	6	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	6	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	6	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	6	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	7	25	13	23	14	17	17	15	19	12	16	16	12	13	10	14	15
R	7	30	18	26	18	20	21	17	23	12	20	22	17	15	11	17	18
R	7	35	26	32	26	27	28	22	27	16	23	25	21	18	16	17	18
R	7	40	33	39	34	35	36	29	33	27	30	31	19	18	18	21	22
R	7	45	39	46	41	43	43	34	38	33	34	35	19	20	18	20	21
R	7	50	47	54	50	49	49	36	45	37	46	49	25	21	22	16	14
R	7	55	59	61	[illegible]	51	48	41	56	51	47	47	25	24	23	13	9

R	7	60	69	68	65	53	48	77	63	58	53	52	33	35	30	18	13
R	7	65	59	76	73	58	53	63	77	73	52	41	32	33	31	21	17
R	7	70	69	77	74	65	62	68	86	81	60	53	42	41	33	21	15
R	7	75	76	81	79	72	68	87	93	85	70	60	49	53	48	28	17
R	7	80	92	95	91	78	73	79	81	84	78	74	51	58	56	37	28
R	7	85	110	116	111	85	74	106	125	120	94	84	65	67	64	51	46
R	7	90	146	133	114	76	62	124	125	137	132	126	103	89	89	86	87
R	7	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	7	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	7	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	7	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	7	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	7	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	8	25	15	23	16	43	47	19	20	16	16	15	15	15	11	32	38
R	8	30	19	30	20	56	63	16	21	16	55	61	16	16	13	30	34
R	8	35	28	41	27	62	70	24	24	18	61	68	19	23	17	31	35
R	8	40	33	60	36	69	78	31	28	27	62	69	18	37	19	28	31
R	8	45	37	69	44	77	87	36	50	33	67	76	19	32	20	21	21
R	8	50	42	106	54	83	91	40	91	40	77	86	19	32	22	15	13
R	8	55	45	124	63	88	95	43	112	53	82	89	18	30	22	16	15
R	8	60	50	126	73	94	100	48	136	62	87	96	26	31	29	21	19
R	8	65	58	98	84	97	100	53	110	79	93	96	32	22	31	23	21
R	8	70	69	89	87	103	107	67	103	93	99	100	43	34	34	23	19
R	8	75	77	87	90	107	112	87	101	100	110	113	49	51	48	31	22
R	8	80	94	95	96	105	107	79	87	97	115	120	52	58	58	42	34
R	8	85	110	113	110	99	95	106	123	124	120	118	65	68	66	58	55
R	8	90	145	131	113	81	68	124	126	138	139	140	104	96	96	93	91
R	8	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	8	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	8	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	8	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	8	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	8	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	9	25	21	19	17	25	27	23	20	17	22	24	14	15	13	15	16
R	9	30	24	24	23	32	35	23	19	15	25	26	15	17	15	17	17
R	9	35	28	34	34	40	43	28	25	20	35	37	16	21	21	24	26
R	9	40	31	43	46	52	55	32	33	31	37	39	19	19	26	32	34
R	9	45	34	52	60	66	71	35	39	40	46	48	19	20	25	29	31
R	9	50	38	63	74	81	86	36	51	55	62	65	21	26	25	27	28
R	9	55	43	69	86	93	95	39	58	69	77	86	19	26	25	24	24
R	9	60	50	78	99	109	115	42	70	81	85	90	25	32	29	35	34
R	9	65	60	88	113	124	137	53	85	104	104	107	31	33	31	40	41
R	9	70	71	90	117	151	160	69	99	122	129	141	43	40	35	35	34
R	9	75	77	91	116	163	174	88	107	131	167	177	49	54	49	40	35
R	9	80	92	92	109	152	163	82	99	126	178	188	52	62	62	52	47
R	9	85	109	106	108	128	135	105	115	133	171	184	66	70	70	73	73
R	9	90	144	127	108	93	88	124	129	140	159	165	107	113	112	108	107
R	9	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	9	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	9	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	9	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	9	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	9	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	10	25	15	28	32	39	41	17	27	23	46	51	14	17	17	20	21

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R   10   30   19   33   42   43   43   18   29   30   36   37   15   20   21   21   21
R   10   35   26   42   55   56   56   21   33   40   36   34   16   21   26   30   35
R   10   40   31   52   69   76   81   28   39   53   50   52   18   24   31   40   44
R   10   45   35   65   84  100  107   35   47   63   66   70   18   29   34   43   47
R   10   50   39   83  100  123  133   36   53   80   92   99   19   38   30   41   45
R   10   55   44  104  114  143  155   41   76   95  117  129   19   36   30   38   38
R   10   60   50  120  128  165  178   44  129  111  132  147   25   39   34   45   45
R   10   65   61  110  144  188  204   53  119  133  160  175   32   27   31   46   49
R   10   70   72  106  148  209  228   71  120  153  189  209   43   35   35   42   42
R   10   75   79  102  144  218  233   90  123  165  233  255   50   54   50   47   45
R   10   80   92   90  124  198  213   84  116  157  238  246   53   65   66   62   58
R   10   85  108   94  104  162  181  103  104  146  224  243   66   72   75   86   86
R   10   90  143  122  102  113  124  125  133  143  184  197  110  133  132  126  123
R   10  100  132  132  132  132  132  154  154  154  154  154   75   75   75   75   75
R   10  120  183  183  183  183  183   79   79   79   79   79  211  211  211  211  211
R   10  140  125  125  125  125  125   72   72   72   72   72  146  146  146  146  146
R   10  160   90   90   90   90   90   65   65   65   65   65  105  105  105  105  105
R   10  180   71   71   71   71   71   58   58   58   58   58   81   81   81   81   81
R   10  200   61   61   61   61   61   52   52   52   52   52   69   69   69   69   69
R   11   25   16   36   24   54   60   17   16   19   43   49   15   26   18   28   30
R   11   30   20   55   34   65   71   19   34   25   56   64   16   28   19   30   33
R   11   35   28   75   44   77   84   24   45   38   66   73   18   38   26   40   42
R   11   40   33   97   53   98  107   30   72   45   75   83   18   41   31   52   56
R   11   45   37  122   66  123  134   36  109   54   97  108   19   33   35   52   56
R   11   50   40  124   80  146  160   39  129   65  117  129   20   24   31   48   52
R   11   55   46  117   93  166  181   40  118   77  146  161   19   20   35   41   41
R   11   60   52  104  108  179  194   48  116   86  164  178   24   23   37   43   44
R   11   65   58   98  125  189  205   55  108  120  188  203   32   27   41   46   48
R   11   70   70   94  127  190  209   69  108  139  200  215   43   39   45   47   49
R   11   75   77   89  121  181  200   88  110  145  209  222   51   61   65   61   60
R   11   80   92   92  114  158  169   82  104  139  204  221   52   63   71   80   83
R   11   85  109  105  111  130  134  102  100  130  185  199   66   71   72   85   90
R   11   90  145  129  112   98   92  128  151  153  153  154  108  121  122  115  113
R   11  100  132  132  132  132  132  154  154  154  154  154   75   75   75   75   75
R   11  120  183  183  183  183  183   79   79   79   79   79  211  211  211  211  211
R   11  140  125  125  125  125  125   72   72   72   72   72  146  146  146  146  146
R   11  160   90   90   90   90   90   65   65   65   65   65  105  105  105  105  105
R   11  180   71   71   71   71   71   58   58   58   58   58   81   81   81   81   81
R   11  200   61   61   61   61   61   52   52   52   52   52   69   69   69   69   69
R   12   25   21   18   45   34   30   21   22   31   31   32   16   17   22   33   35
R   12   30   24   24   57   55   53   24   21   51   40   36   18   21   24   39   42
R   12   35   31   33   62   71   73   29   29   64   60   61   19   24   29   52   58
R   12   40   36   43   67   99  105   35   40   65   64   65   19   29   38   58   63
R   12   45   39   52   79  129  138   39   49   73   98  104   20   29   41   52   54
R   12   50   42   61   89  153  165   41   49   82  127  137   21   24   35   46   48
R   12   55   47   69   97  168  182   44   64   92  161  173   18   27   38   48   49
R   12   60   51   76  107  175  189   50   73   94  175  188   23   36   39   50   53
R   12   65   57   88  114  171  186   53   90  121  187  203   31   39   47   51   54
R   12   70   69   79  111  161  176   68   93  131  199  203   44   45   49   53   55
R   12   75   76   78  103  141  152   86   97  129  182  195   52   67   73   70   69
R   12   80   94   93  106  118  171   80   95  123  167  179   52   61   75   92   97
R   12   85  110  112  114  104  100  102   96  117  147  156   65   70   70   84   87
R   12   90  146  133  118   98   72  130  163  159  127  114  106  111  114  107  105
R   12  100  132  132  132  132  132  154  154  154  154  154   75   75   75   75   75
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R      12   120   183   183   183   183   183    79    79    79    79    79   211   211   211   211   211
R      12   140   125   125   125   125   125    72    72    72    72    72   146   146   146   146   146
R      12   160    90    90    90    90    90    65    65    65    65    65   105   105   105   105   105
R      12   180    71    71    71    71    71    58    58    58    58    58    81    81    81    81    81
R      12   200    61    61    61    61    61    52    52    52    52    52    69    69    69    69    69
R      13    25    20    38    46    77    95    22    30    35    58    77    15    19    30    43    98
R      13    30    24    46    63   104   126    21    39    40    74    92    17    24    38    53   104
R      13    35    33    56    90   136   159    28    45    57    92   113    21    26    49    62   110
R      13    40    40    67   118   177   202    34    57    82   120   139    21    29    71    85   114
R      13    45    46    76   145   220   250    41    67   111   161   183    23    27    50    70   122
R      13    50    54    88   167   255   289    49    78   138   209   236    22    26    41    60    75
R      13    55    59    96   184   282   321    56    86   162   244   277    20    28    39    56    63
R      13    60    63   104   199    3.   353    66   102   183   272   306    29    33    39    58    92
R      13    65    65   104   209   331   386    61   108   208   304   342    35    35    44    50    77
R      13    70    77   102   203   349   416    74   116   226   342   391    46    44    54    44    67
R      13    75    86   100   182   341   422    94   120   227   377   441    52    62    80    65    59
R      13    80   102   102   152   290   377    90   111   212   385   469    54    65   106   116    94
R      13    85   121   116   135   195   281   112   118   191   332   423    68    74   128   164   171
R      13    90   158   140   173   134   194   135   149   180   219   298   109   117   165   185   199
R      13   100   192   192   192   192   192   224   224   224   224   224    97    97    97    97    97
R      13   120   183   183   183   183   183    79    79    79    79    79   211   211   211   211   211
R      13   140   125   125   125   125   125    72    72    72    72    72   146   146   146   146   146
R      13   160    90    90    90    90    90    65    65    65    65    65   105   105   105   105   105
R      13   180    71    71    71    71    71    58    58    58    58    58    81    81    81    81    81
R      13   200    61    61    61    61    61    52    52    52    52    52    69    69    69    69    69

***RANDOM WINDS,  CODE RW***
RW      1     0     2     5     7     6     6     3     5     6     5     5
RW      1     5     6    10    13    11    11     4     9    12    11    11
RW      1    10     8    15    15    12    11     7    14    15    12    11
RW      1    15     9    11    11    10    10     7    10    10    11    11
RW      1    20    10     8    11    12    13     5     5     9    13    14
RW      1    25    12     9    20    21    21     2     4    11    17    18
RW      1    30    15    13    25    27    27     4     6    15    20    21
RW      1    35    17    18    29    29    28     7    10    17    27    29
RW      1    40    18    22    36    30    27     6    11    20    33    37
RW      1    45    24    27    46    33    27    11    14    22    40    45
RW      1    50    23    29    50    36    29    13    16    28    45    50
RW      1    55    21    29    44    38    35    16    16    25    42    46
RW      1    60    21    29    37    38    38    16    19    26    39    43
RW      1    65    21    38    45    37    35    21    25    38    47    49
RW      1    70    30    42    44    34    30    17    22    32    47    50
RW      1    75    35    38    45    51    52    32    43    46    42    40
RW      1    80    31    33    45    61    66    37    47    62    64    65
RW      1    85    41    33    46    73    80    56    61    76    81    82
RW      1    90    76    54    63    81    87    79   118   121   115   112
RW      1   100    74    59    58    53    53    75   102    87    53    53
RW      1   120    72    64    62    52    52    72    85    52    52    52
RW      1   140    69    69    69    69    69    69    69    69    69    69
RW      1   160    87    87    87    87    87    87    87    87    87    87
RW      1   190    87    87    87    87    87    87    87    87    87    87
RW      1   200    87    87    87    87    87    87    87    87    87    87
RW      2     0     2     5     6     6     6     2     6     5     6     6
RW      2     5     6    10    12    11    10     4     9    12    11    11
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RW	2	10	8	16	15	12	11	7	15	14	12	12
RW	2	15	9	12	10	11	11	7	11	9	11	12
RW	2	20	10	8	10	13	14	4	5	7	13	14
RW	2	25	12	9	14	16	17	3	3	12	12	13
RW	2	30	14	12	17	20	21	4	6	15	21	23
RW	2	35	16	19	22	21	20	7	8	17	25	27
RW	2	40	19	23	29	25	24	6	10	19	28	31
RW	2	45	24	26	35	31	30	10	13	21	33	36
RW	2	50	22	27	38	33	31	11	13	24	33	36
RW	2	55	20	27	39	39	38	16	15	21	31	34
RW	2	60	21	27	35	35	34	16	17	23	30	32
RW	2	65	20	37	44	36	34	21	24	36	44	47
RW	2	70	30	41	43	34	30	17	22	31	44	48
RW	2	75	35	38	45	49	50	32	41	45	42	41
RW	2	80	31	33	44	59	63	37	47	61	63	64
RW	2	85	41	35	46	57	60	56	61	74	60	61
RW	2	90	76	54	62	55	57	78	113	118	57	56
RW	2	100	63	44	57	53	53	63	44	57	53	53
RW	2	120	50	57	52	52	52	50	57	52	52	52
RW	2	140	69	69	69	69	69	69	69	69	69	69
RW	2	160	87	87	87	87	87	87	87	87	87	87
RW	2	180	87	87	87	87	87	87	87	87	87	87
RW	2	200	87	87	87	87	87	87	87	87	87	87
RW	3	0	2	5	6	5	5	3	5	6	5	5
RW	3	5	6	9	11	11	11	4	9	11	11	11
RW	3	10	8	15	14	11	10	7	14	14	11	10
RW	3	15	9	12	9	9	9	7	10	9	10	10
RW	3	20	10	7	9	11	11	4	5	7	10	11
RW	3	25	13	7	13	14	14	3	3	8	19	21
RW	3	30	13	11	13	15	15	4	4	8	19	22
RW	3	35	16	18	20	20	20	7	8	12	20	22
RW	3	40	19	19	26	24	23	6	8	13	21	24
RW	3	45	24	22	31	30	29	9	10	14	23	25
RW	3	50	21	22	32	29	28	10	11	17	23	25
RW	3	55	20	23	32	32	32	16	14	19	23	24
RW	3	60	22	26	31	32	32	15	16	20	25	27
RW	3	65	20	36	40	34	31	20	22	30	36	38
RW	3	70	29	38	40	32	29	17	21	28	38	40
RW	3	75	35	39	43	44	44	32	37	41	42	42
RW	3	80	31	34	41	52	55	37	47	59	60	61
RW	3	85	42	39	46	52	54	56	61	71	58	58
RW	3	90	76	56	56	53	54	76	100	109	55	56
RW	3	100	73	60	54	53	53	73	90	81	53	53
RW	3	120	71	65	52	52	52	71	79	52	52	52
RW	3	140	69	69	69	69	69	69	69	69	69	69
RW	3	160	87	87	87	87	87	87	87	87	87	87
RW	3	180	87	87	87	87	87	87	87	87	87	87
RW	3	200	87	87	87	87	87	87	87	87	87	87
RW	4	0	2	4	5	5	5	2	5	6	5	5
RW	4	5	5	8	11	10	10	4	8	12	11	10
RW	4	10	7	14	15	11	9	6	13	16	11	9
RW	4	15	7	11	9	9	10	6	10	9	8	8
RW	4	20	9	7	8	11	11	4	5	6	8	9
RW	4	25	12	5	5	7	8	3	3	3	5	5

RW	4	30	12	8	8	9	10	4	4	4	6	7
RW	4	35	17	14	14	11	11	8	6	8	8	9
RW	4	40	17	15	16	13	12	5	7	9	11	12
RW	4	45	23	19	20	16	15	9	8	9	10	10
RW	4	50	20	20	22	18	17	11	8	10	11	12
RW	4	55	21	22	25	21	26	16	12	15	14	14
RW	4	60	21	26	29	25	23	15	13	15	16	16
RW	4	65	20	34	35	29	27	20	19	20	21	21
RW	4	70	28	35	35	30	28	17	19	24	26	26
RW	4	75	36	40	41	35	33	31	31	36	42	44
RW	4	80	31	34	38	41	42	37	47	54	56	57
RW	4	85	43	45	46	45	46	56	62	65	55	56
RW	4	90	77	59	48	49	49	72	77	95	54	54
RW	4	100	74	65	50	53	53	71	74	74	53	53
RW	4	120	72	71	52	52	52	70	71	52	52	52
RW	4	140	69	69	69	69	69	69	69	69	69	69
RW	4	160	87	87	67	87	87	87	87	87	87	87
RW	4	180	87	87	87	87	87	87	87	87	87	87
RW	4	200	87	87	87	87	87	87	87	87	87	87
RW	5	0	2	4	5	5	5	2	4	6	5	5
RW	5	5	5	7	11	10	9	4	7	11	10	9
RW	5	10	6	12	15	11	9	5	11	15	11	9
RW	5	15	8	10	9	6	5	6	10	9	6	5
RW	5	20	7	6	7	5	4	4	5	5	5	5
RW	5	25	12	4	3	3	3	3	2	2	3	4
RW	5	30	14	8	6	5	4	8	3	3	3	3
RW	5	35	15	10	10	8	8	9	6	7	5	5
RW	5	40	16	11	10	11	11	6	6	7	7	7
RW	5	45	22	15	14	18	19	19	8	8	8	8
RW	5	50	20	13	14	20	22	21	8	8	10	11
RW	5	55	19	15	16	28	31	23	10	12	11	11
RW	5	60	22	19	20	17	17	29	14	15	15	15
RW	5	65	18	28	29	23	21	20	20	20	18	18
RW	5	70	29	30	30	25	23	18	25	26	21	19
RW	5	75	35	39	41	35	33	31	32	42	45	46
RW	5	80	31	38	43	43	43	37	48	52	49	48
RW	5	85	44	52	55	46	46	56	61	61	50	50
RW	5	90	79	82	72	50	50	73	86	98	52	51
RW	5	100	76	78	62	53	53	72	80	75	53	53
RW	5	120	72	73	52	52	52	70	75	52	52	52
RW	5	140	69	69	69	69	69	69	69	69	69	69
RW	5	160	87	67	87	87	87	87	87	87	87	87
RW	5	180	87	87	87	87	87	87	87	87	87	87
RW	5	200	87	87	87	87	87	67	87	87	87	87
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RW	6	15	7	10	9	6	5	6	8	8	6	6
RW	6	20	7	6	6	5	4	4	5	5	4	4
RW	6	25	11	5	3	3	3	3	8	2	2	2
RW	6	30	12	7	4	3	3	3	8	2	2	2
RW	6	35	13	8	7	5	5	7	8	6	4	4
RW	6	40	17	9	8	6	6	6	8	6	5	4
RW	6	45	23	13	10	8	8	10	9	8	5	4

RW	6	50	20	13	41	10	10	10	10	10	7	5
RW	6	55	20	15	13	15	16	15	13	10	8	8
RW	6	60	20	16	15	15	16	15	13	17	13	14
RW	6	65	17	22	23	18	16	20	20	20	16	15
RW	6	70	27	26	26	21	20	18	28	27	17	12
RW	6	75	35	38	41	35	33	31	32	46	47	48
RW	6	80	32	41	47	44	43	37	49	51	43	40
RW	6	85	45	57	61	47	46	56	61	58	46	44
RW	6	90	81	95	86	50	50	75	92	100	50	49
RW	6	100	77	86	69	53	53	73	85	76	53	53
RW	6	120	73	77	52	52	52	71	79	52	52	52
RW	6	140	69	69	69	69	69	69	69	69	69	69
RW	6	160	87	87	87	87	87	87	87	87	87	87
RW	6	180	87	87	87	87	87	87	87	87	87	87
RW	6	200	87	87	87	87	87	87	87	87	87	87
RW	7	0	2	3	4	4	4	2	3	5	4	4
RW	7	5	5	6	8	9	9	4	5	8	8	8
RW	7	10	6	8	14	12	11	4	7	14	12	11
RW	7	15	7	8	9	7	5	5	7	9	6	5
RW	7	20	7	5	6	4	4	4	4	5	4	3
RW	7	25	11	3	2	2	2	4	3	2	2	2
RW	7	30	12	4	3	2	2	4	3	2	2	2
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RW	7	45	20	11	10	5	4	9	8	8	4	4
RW	7	50	24	9	9	6	4	11	8	7	5	5
RW	7	55	20	12	12	9	7	14	11	10	8	7
RW	7	60	25	17	12	8	7	19	15	18	13	11
RW	7	65	17	20	20	15	13	20	20	20	16	14
RW	7	70	27	24	24	20	18	18	29	27	15	8
RW	7	75	35	38	41	35	33	31	33	47	48	48
RW	7	80	32	42	48	45	44	37	49	50	41	37
RW	7	85	45	59	63	55	53	56	61	57	46	42
RW	7	90	82	100	91	76	70	75	94	101	80	72
RW	7	100	78	84	72	53	53	73	81	77	53	53
RW	7	120	73	67	52	52	52	71	67	52	52	52
RW	7	140	69	69	69	69	69	69	69	69	69	69
RW	7	160	87	87	87	87	87	87	87	87	87	87
RW	7	180	87	87	87	87	87	87	87	87	87	87
RW	7	200	87	87	87	87	87	87	87	87	87	87
RW	8	0	2	3	5	5	5	2	3	4	4	4
RW	8	5	5	5	8	9	[illegible]	4	5	9	8	8
RW	8	10	6	8	13	12	1	5	8	14	12	11
RW	8	15	7	8	10	7	6	5	7	10	7	5
RW	8	20	7	5	6	5	4	4	4	5	4	4
RW	8	25	10	3	3	3	3	3	2	2	2	2
RW	8	30	13	4	4	5	5	5	3	2	2	2
RW	8	35	14	7	6	6	7	7	6	5	3	3
RW	8	40	17	10	8	8	8	6	6	6	4	3
RW	8	45	24	13	11	8	7	9	9	8	5	4
RW	8	50	21	13	11	9	8	10	10	8	6	6
RW	8	55	17	17	13	12	11	13	12	11	8	7
RW	8	60	18	19	19	15	14	16	14	17	14	14
RW	8	65	17	22	23	18	16	20	20	20	16	15

RW	8	70	27	26	26	21	20	18	28	27	17	12
RW	8	75	35	38	41	35	33	31	32	46	47	48
RW	8	80	32	41	47	44	43	37	49	51	43	40
RW	8	85	45	57	61	47	46	56	61	58	46	44
RW	8	90	81	95	86	50	50	75	92	100	50	49
RW	8	100	100	87	69	53	53	100	85	76	53	53
RW	8	120	90	78	52	52	52	90	77	52	52	52
RW	8	140	69	69	69	69	69	69	69	69	69	69
RW	8	160	87	87	87	87	87	87	87	87	87	87
RW	8	180	87	87	87	87	87	87	87	87	87	87
RW	8	200	87	87	87	87	87	87	87	87	87	87
RW	9	0	2	4	5	6	6	2	3	5	5	5
RW	9	5	4	6	10	9	9	3	6	10	9	9
RW	9	10	5	10	15	12	10	4	9	16	12	10
RW	9	15	7	9	10	7	5	5	8	10	7	6
RW	9	20	8	6	7	5	5	4	4	6	5	5
RW	9	25	11	4	4	5	6	3	3	3	3	3
RW	9	30	13	6	5	7	8	3	5	3	5	5
RW	9	35	14	10	10	9	10	6	6	7	6	7
RW	9	40	19	12	11	12	13	5	7	7	8	9
RW	9	45	22	15	15	13	13	8	8	9	7	7
RW	9	50	16	15	15	15	15	8	8	9	9	9
RW	9	55	16	16	18	18	18	13	12	12	9	8
RW	9	60	18	20	22	21	21	14	13	16	17	17
RW	9	65	18	28	29	23	21	20	20	20	18	18
RW	9	70	28	30	30	25	23	18	25	26	21	19
RW	9	75	35	39	41	35	33	31	32	42	45	46
RW	9	80	31	38	43	43	43	37	48	52	49	48
RW	9	85	44	52	55	46	46	56	61	61	50	50
RW	9	90	79	82	72	50	50	73	86	98	51	51
RW	9	100	71	67	62	53	53	71	55	56	53	53
RW	9	120	64	51	52	52	52	64	51	52	52	52
RW	9	140	69	69	69	69	69	69	69	69	69	69
RW	9	160	87	87	87	87	87	87	87	87	87	87
RW	9	180	87	87	87	87	87	87	87	87	87	87
RW	9	200	87	87	87	87	87	87	87	87	87	87
RW	10	0	3	4	6	5	5	2	4	6	5	5
RW	10	5	5	7	11	10	9	4	7	12	10	9
RW	10	10	6	12	15	13	13	5	11	16	12	10
RW	10	15	7	11	10	9	8	5	9	11	8	7
RW	10	20	8	7	7	8	8	4	5	7	8	8
RW	10	25	12	6	7	9	9	4	3	6	9	9
RW	10	30	15	8	9	9	9	4	4	7	11	12
RW	10	35	16	15	14	12	11	6	6	9	13	15
RW	10	40	17	19	16	13	12	6	6	11	14	15
RW	10	45	19	22	21	15	13	8	8	12	14	15
RW	10	50	16	22	23	19	16	9	9	12	16	17
RW	10	55	17	22	26	23	22	13	13	16	18	18
RW	10	60	21	26	29	29	27	16	13	16	22	24
RW	10	65	20	34	35	29	27	20	19	20	21	21
RW	10	70	28	35	35	30	28	17	19	24	26	26
RW	10	75	36	40	41	35	33	31	31	36	42	44
RW	10	80	31	34	38	41	42	37	47	54	56	57
RW	10	85	43	45	46	45	46	56	62	65	55	56

RW	10	90	77	59	48	49	49	72	77	95	54	54
RW	10	100	74	60	50	53	53	71	69	50	53	53
RW	10	120	72	60	52	52	52	70	60	52	52	52
RW	10	140	69	69	69	69	69	69	69	69	69	69
RW	10	160	87	87	87	87	87	87	87	87	87	97
RW	10	180	87	87	87	87	87	87	87	87	87	87
RW	10	200	87	87	87	87	87	87	87	87	87	87
RW	11	0	3	5	6	6	6	2	5	6	6	5
RW	11	5	5	8	11	11	10	4	8	12	11	11
RW	11	10	7	13	15	12	10	6	12	16	12	11
RW	11	15	8	11	10	8	8	6	10	10	9	9
RW	11	20	9	7	8	9	9	4	5	7	10	10
RW	11	25	11	7	8	11	12	3	4	7	13	15
RW	11	30	16	12	12	12	11	4	6	9	17	18
RW	11	35	13	26	18	15	15	7	8	12	19	21
RW	11	40	16	18	19	20	21	5	9	13	19	21
RW	11	45	22	20	23	25	26	9	12	14	20	22
RW	11	50	20	22	27	25	24	10	13	18	24	26
RW	11	55	21	23	29	32	32	14	15	20	23	24
RW	11	60	21	24	31	32	31	15	17	21	26	27
RW	11	65	20	36	40	34	31	20	22	30	36	38
RW	11	70	29	38	40	32	29	17	21	28	38	40
RW	11	75	35	39	43	44	44	32	37	41	42	42
RW	11	80	31	34	41	52	55	37	47	59	60	61
RW	11	85	42	39	46	52	54	56	61	71	58	58
RW	11	90	76	56	56	53	54	76	100	109	55	56
RW	11	100	74	60	54	53	53	74	90	81	53	53
RW	11	120	71	65	52	52	52	71	79	52	52	52
RW	11	140	69	69	69	69	69	69	69	69	69	69
RW	11	160	87	87	87	87	87	87	87	87	87	87
RW	11	180	87	87	87	87	87	87	87	87	87	87
RW	11	200	87	87	87	87	87	87	87	87	87	87
RW	12	0	2	5	7	6	6	3	5	6	6	6
RW	12	5	5	9	12	11	11	4	9	12	11	11
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RW	12	20	10	8	10	10	11	4	6	9	11	12
RW	12	25	10	34	14	14	13	2	34	10	12	13
RW	12	30	17	13	19	18	18	4	6	14	19	21
RW	12	35	17	20	22	22	23	8	9	18	23	25
RW	12	40	20	24	23	27	28	7	13	22	28	30
RW	12	45	27	29	27	30	30	11	14	23	29	31
RW	12	50	25	31	31	32	31	12	15	25	30	30
RW	12	55	23	32	33	35	35	17	17	23	31	33
RW	12	60	23	29	34	35	35	18	21	23	30	32
RW	12	65	20	37	44	36	34	21	24	36	44	47
RW	12	70	30	41	43	34	30	17	22	31	44	48
RW	12	75	35	38	45	49	50	32	41	45	42	41
RW	12	80	31	33	44	59	63	37	47	61	63	64
RW	12	85	41	35	46	57	60	56	61	74	60	60
RW	12	90	76	54	62	55	56	78	113	118	56	57
RW	12	100	74	59	57	53	53	75	99	85	53	53
RW	12	120	72	64	52	52	52	72	84	52	52	52
RW	12	140	69	69	69	69	69	69	69	69	69	69

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RW    12   160    87    87    87    87    87    87    87    87    87    87
RW    12   180    87    87    87    87    87    87    87    87    87    87
RW    12   200    87    87    87    87    87    87    87    87    87    87
RW    13     0     3     5     6     5     5     3     5     6     5     5
RW    13     5     6    10    11    10    10     4     8    11    10    10
RW    13    10     8    18    15    12    11     6    12    15    12    11
RW    13    15    10    16    10     9     9     6    10    10     9     9
RW    13    20    10    11    10    11    11     4     5     7     9    10
RW    13    25    11    11    10    11    11     3    10     7    10    11
RW    13    30    14     9    12    13    13     4     5     9    13    14
RW    13    35    15    15    16    16    15     7     7    11    16    17
RW    13    40    17    17    20    18    18     6     8    13    18    20
RW    13    45    23    20    24    22    21    11    10    14    20    22
RW    13    50    21    21    29    23    22    12    11    16    22    24
RW    13    55    20    22    27    27    27    16    13    17    22    23
RW    13    60    21    24    27    27    26    17    16    19    23    25
RW    13    65    19    32    35    29    27    20    21    27    30    31
RW    13    70    28    34    35    29    26    17    24    28    32    33
RW    13    75    35    39    42    41    40    31    35    43    44    44
RW    13    80    31    36    43    49    51    37    48    56    55    54
RW    13    85    43    47    52    52    54    56    61    66    56    56
RW    13    90    78    73    68    57    57    75    97   106    63    62
RW    13   100    76    69    60    53    53    75    81    74    53    53
RW    13   120    72    76    52    52    52    71    72    52    52    52
RW    13   140    69    69    69    69    69    69    69    69    69    69
RW    13   160    87    87    87    87    87    87    87    87    87    87
RW    13   180    87    87    87    87    87    87    87    87    87    87
RW    13   200    87    87    87    87    87    87    87    87    87    87

----- END OF FILE WRITTEN -----

***P, D, T ANNUAL PERCENTS,  CODE P***
P     13     0   761   599   498   435   415   633   504   414   361   341   485   495   762   829   852
P     13     5   734   610   535   498   473   617   522   455   417   401   472   495   758   827   851
P     13    10   707   622   572   540   530   601   540   497   472   461   459   496   753   825   850
P     13    15   679   633   608   592   587   586   557   538   527   522   447   496   749   824   849
P     13    20   652   644   645   644   645   570   575   579   582   582   434   497   745   822   848
P     13    25   621   643   663   673   677   616   613   611   611   610   445   519   732   803   827
P     13    30   607   672   719   747   757   500   591   656   695   707   390   454   740   828   857
P     13    35   571   696   784   838   856   459   613   722   788   810   362   520   752   850   883
P     13    40   531   692   808   877   900   508   654   758   821   841   412   588   714   790   815
P     13    45   523   690   802   869   892   534   670   766   824   844   440   551   630   678   693
P     13    50   495   667   789   863   887   491   649   762   830   853   418   493   545   577   588
P     13    55   471   646   770   846   871   483   636   746   812   834   430   472   502   520   526
P     13    60   517   655   753   813   832   587   673   734   771   784   544   570   588   600   604
P     13    65   550   642   707   747   760   681   710   730   742   747   677   703   722   733   737
P     13    70   583   629   662   682   688   648   663   673   679   681   574   587   597   602   604
P     13    75   616   616   616   616   616   615   615   615   615   615   471   471   471   471   471
P     13    80   637   637   637   637   637   571   571   571   571   571   455   455   455   455   455
P     13    85   657   657   657   657   657   526   526   526   526   526   439   439   439   439   439
P     13    90   678   678   678   678   678   482   482   482   482   482   422   422   422   422   422
P     13   100   719   719   719   719   719   393   393   393   393   393   390   390   390   390   390
P     13   120   599   599   599   599   599   328   328   328   328   328   325   325   325   325   325
P     13   140   479   479   479   479   479   262   262   262   262   262   260   260   260   260   260
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P     13   160   360   360   360   360   360   197   197   197   197   197   195   195   195   195   195
P     13   180   240   240   240   240   240   131   131   131   131   131   130   130   130   130   130
P     13   200   120   120   120   120   120    66    66    66    66    66    65    65    65    65    65
PW    13     0   961   911   866   873   828   320   606   921   693   733
PW    13     5   941   904   869   847   840   321   599   892   721   759
PW    13    10   922   897   873   857   852   323   591   864   748   785
PW    13    15   903   890   876   867   864   324   583   835   775   810
PW    13    20   884   883   880   877   876   327   575   806   803   836
PW    13    25   864   878   887   892   894   344   575   739   839   872
PW    13    30   854   872   885   892   895   324   552   751   832   859
PW    13    35   821   858   885   901   906   304   545   786   890   918
PW    13    40   794   854   896   921   930   328   550   706   944   974
PW    13    45   798   853   899   927   937   349   537   618   920   943
PW    13    50   768   831   876   903   912   339   489   650   856   889
PW    13    55   734   761   781   793   797   366   450   649   771   811
PW    13    60   721   686   662   647   642   469   550   674   749   773
PW    13    65   743   720   704   694   690   601   713   794   842   858
PW    13    70   765   753   745   740   739   694   750   790   814   822
PW    13    75   787   787   787   787   787   787   787   787   787   787
PW    13    80   760   760   760   760   760   760   760   760   760   760
PW    13    85   734   734   734   734   734   734   734   734   734   734
PW    13    90   707   707   707   707   707   707   707   707   707   707
PW    13   100   654   654   654   654   654   654   654   654   654   654
PW    13   120   615   615   615   615   615   615   615   615   615   615
PW    13   140   575   575   575   575   575   575   575   575   575   575
PW    13   160   536   536   536   536   536   536   536   536   536   536
PW    13   180   496   496   496   496   496   496   496   496   496   496
PW    13   200   457   457   457   457   457   457   457   457   457   457

***SMALL & LARGE SCALE U-D AND V-D ANNUAL CORRELATIONS,  CODE CS, CL***
CS    13     0   -55   -17   -47   -65   -70   108   -27  -122  -181  -201
CS    13     5   -61   -22   -42   -54   -58    82   -29  -107  -156  -173
CS    13    10   -67   -26   -38   -44   -46    56   -32   -93  -131  -144
CS    13    15   -74   -31   -33   -34   -34    30   -34   -78  -106  -116
CS    13    20   -80   -36   -28   -24   -22     4   -36   -64   -62   -88
CS    13    25   -86   -71   -60   -54   -52     1   -73  -125  -157  -168
CS    13    30  -122   -67   -28    -4     4   -56   -75   -88   -97  -100
CS    13    35  -113   -46     2    30    40   -75   -25    11    32    39
CS    13    40   -72    -8    37    65    75  -101    15    98   147   163
CS    13    45   -51    -9    22    40    46  -152    -8    95   157   177
CS    13    50  -107   -52   -12    10    18  -169   -38    55   111   129
CS    13    55  -213   -89     0    52    70  -183   -72     8    56    72
CS    13    60  -102  -108   -15    41    60  -173   -93   -37    -2     9
CS    13    65  -137   -77    15    68    87  -231   -56    68   143   168
CS    13    70  -143   -82    19    79    99  -256   -58    82   168   196
CS    13    75  -149   -86    24    89   112  -283   -61    97   193   225
CS    13    80  -155   -91    29    99   124  -309   -63   112   219   253
CS    13    85  -162   -96    34   110   136  -335   -65   126   243   281
CS    13    90  -168  -100    38   120   148  -361   -67   141   268   310
CS    13   100  -181  -109    48   140   172  -413   -72   170   318   366
CS    13   120  -181  -109    48   140   172  -413   -72   170   318   366
CS    13   140  -181  -109    48   140   172  -413   -72   170   318   366
CS    13   160  -181  -109    48   140   172  -413   -72   170   318   366
CS    13   180  -181  -109    48   140   172  -413   -72   170   318   366
CS     13    200   -161   -109     48    140    172   -413    -72    170    318    366
CL     13      0    308   -207   -576   -796   -869     23    145    235    289    309
CL     13      5    289   -202   -553   -763   -832     23    136    218    268    287
CL     13     10    270   -197   -530   -729   -795     23    126    202    248    265
CL     13     15    251   -191   -507   -696   -759     24    117    185    227    242
CL     13     20    232   -186   -484   -663   -722     24    107    169    207    220
CL     13     25    283   -150   -459   -644   -705    -18     69    131    169    182
CL     13     30    223   -159   -432   -595   -650     74    116    147    165    172
CL     13     35     56   -202   -385   -495   -532     30    107    163    196    207
CL     13     40     96   -183   -382   -502   -542     -4     40     71     90     96
CL     13     45    163   -170   -407   -549   -596     34    -30    -76   -102   -111
CL     13     50    137   -180   -405   -540   -586     50    -47   -116   -157   -171
CL     13     55    126   -144   -335   -450   -489     36    -50   -110   -146   -159
CL     13     60     79   -108   -240   -320   -347     -2    -84   -143   -178   -190
CL     13     65     60   -138   -277   -361   -390     26    -94   -160   -200   -214
CL     13     70     41   -133   -254   -328   -353     26   -111   -180   -222   -237
CL     13     75     22   -127   -231   -294   -316     27   -127   -199   -243   -259
CL     13     80      3   -122   -208   -261   -280     27   -144   -219   -265   -282
CL     13     85    -16   -117   -185   -227   -243     27   -160   -238   -287   -304
CL     13     90    -36   -111   -162   -194   -206     27   -177   -258   -309   -327
CL     13    100    -74   -101   -116   -127   -132     28   -210   -297   -352   -372
CL     13    120    -74   -101   -116   -127   -132     28   -210   -297   -352   -372
CL     13    140    -74   -101   -116   -127   -132     28   -210   -297   -352   -372
CL     13    160    -74   -101   -116   -127   -132     28   -210   -297   -352   -372
CL     13    180    -74   -101   -116   -127   -132     28   -210   -297   -352   -372
CL     13    200    -74   -101   -116   -127   -132     28   -210   -297   -352   -372

----- END OF FILE WRITTEN -----

***QUASI-BIENNIAL OSCILLATIONS,  CODE QP, QD, QT, QU, OR QV***
QP     15      1    291      1    807      1    554      1    404      1    353
QP     20      2    248      2    778      2    537      2    392      2    344
QP     25      3    369      3    811      3    506      3    323      3    262
QP     30      6     63      8    675     10    491     11    381     12    344
QP     35      8     49     15    669     20    491     23    385     24    349
QP     40      9     39     22    665     31    491     37    387     39    352
QP     45      8     27     26    645     39    465     47    357     49    321
QP     50      9    839     27    595     40    422     48    317     50    282
QP     55     11    825     26    574     37    395     43    288     45    251
QP     60     16    537     31    580     42    396     49    285     51    249
QP     65     13    732     26    525     35    378     41    289     43    259
QP     70     11    689     21    497     28    360     33    277     34    250
QP     75      8    646     16    469     21    342     25    266     26    240
QP     80      5    603     10    441     14    325     16    254     17    231
QP     85      3    560      5    413      7    307      8    243      9    222
QP     90      0    517      0    384      0    289      0    231      0    212
QD     15      5    428      2    151      1    823      0    704      0    665
QD     20     10    368      5     95      1    770      1    653      1    614
QD     25     15    410      7    188      2     30      1    805      1    773
QD     30      6    287      5    807      4    557      4    407      3    357
QD     35      6     76      9    699     11    523     12    417     13    382
QD     40      8     66     15    695     20    522     23    419     24    384
QD     45      9     40     24    668     35    496     42    393     44    358
QD     50      8    869     28    625     43    450     52    346     55    311
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GS	55	8	842	26	589	38	408	46	299	48	263
GS	60	15	829	19	584	22	409	24	304	24	269
GS	65	13	704	16	466	18	296	20	194	20	160
GS	70	10	645	13	411	15	243	16	143	16	110
GS	75	8	585	10	355	11	191	12	92	12	59
GS	80	5	526	6	300	7	138	8	41	8	9
GS	85	3	466	3	244	4	85	4	860	4	828
GS	90	0	407	0	189	0	33	0	809	0	778
GT	15	4	10	3	695	2	563	2	483	2	457
GT	20	6	4	6	673	4	529	4	443	4	414
GT	25	11	18	9	626	7	439	6	327	6	290
GT	30	9	9	10	636	10	462	11	357	11	322
GT	35	3	853	9	631	14	473	17	378	18	346
GT	40	1	810	9	603	16	455	19	367	21	337
GT	45	4	3	8	580	10	370	12	245	12	203
GT	50	1	794	2	492	3	283	4	157	4	115
GT	55	2	811	4	514	4	302	5	175	5	132
GT	60	6	18	6	513	5	245	5	85	5	31
GT	65	5	822	5	476	4	228	4	80	4	29
GT	70	4	817	4	454	3	194	3	40	3	856
GT	75	3	811	3	432	3	161	3	869	3	814
GT	80	2	805	2	410	2	128	2	829	2	771
GT	85	1	799	1	388	1	94	1	788	1	728
GT	90	0	794	0	366	0	61	0	748	0	685
GU	15	42	655	25	586	14	537	6	507	4	497
GU	20	84	504	51	505	27	505	13	506	8	505
GU	25	126	325	76	390	41	436	19	463	12	472
GU	30	158	205	99	355	57	462	31	526	23	547
GU	35	146	79	93	280	56	424	33	511	25	539
GU	40	56	843	47	221	40	398	37	505	35	540
GU	45	21	591	24	102	26	374	27	537	28	591
GU	50	49	289	43	793	39	282	36	498	35	570
GU	55	61	421	55	845	51	278	48	460	47	520
GU	60	52	159	47	721	44	253	41	494	40	574
GU	65	44	7	39	640	36	221	34	493	34	583
GU	70	35	725	31	558	29	190	27	492	27	592
GU	75	26	573	24	476	22	158	21	490	20	600
GU	80	17	421	16	395	15	127	14	489	13	609
GU	85	9	269	8	313	7	95	7	488	7	618
GU	90	0	118	0	231	0	63	0	486	0	626
GV	15	1	226	3	91	5	866	7	809	7	790
GV	20	1	264	6	140	11	53	13	0	14	853
GV	25	1	438	9	246	16	109	20	27	21	0
GV	30	1	404	9	270	15	175	19	117	20	98
GV	35	8	274	13	245	17	225	20	213	20	209
GV	40	6	174	16	238	22	284	26	312	28	321
GV	45	7	441	11	363	14	308	16	275	16	264
GV	50	1	544	19	453	31	389	39	350	41	337
GV	55	5	647	11	543	15	469	17	424	18	409
GV	60	4	571	9	533	13	507	15	491	15	485
GV	65	4	609	8	582	11	564	12	552	13	548
GV	70	3	648	6	632	9	621	10	614	10	611
GV	75	2	686	5	681	6	678	7	675	8	674
GV	80	1	724	3	730	4	734	5	737	5	737

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GV     65      1    763      2    779      2    791      2    798      3    800
GV     90      0    801      0    828      0    849      0    859      0    863

----- END OF FILE WRITTEN -----

***SPHERICAL HARMONICS COEFFICIENTS,  CODE SP***
SP     25      1   -711    840    245    675   1108    -20    245     86     62
SP     30      1   -881   1246    272    770   1016     87    347    140      3
SP     35      1  -1051   1566    160   1006   1014    351    393     46   -221
SP     40      1  -1302   1834     85   1243   1499    416    288    -12   -475
SP     45      1  -1367   2771    -88   1384   2240    768   -131   -166   -642
SP     50      1  -1242   3707   -117   1218   2056    850   -298   -202   -783
SP     55      1   -591   3511   -638   2072   -255   1210   -447    -98   -920
SP     60      1    221   3594   -379   2791  -2082   1333   -683    -44  -1075
SP     65      1  -1197   4623    -66   3334  -4594   -355   2211    574   -442
SP     70      1    559   3331   -237   2488      0      0      0      0      0
SP     75      1    641   2705     16   2047      0      0      0      0      0
SP     80      1    607   2290     29    507      0      0      0      0      0
SP     85      1   1206    933   -595    139      0      0      0      0      0
SP     90      1    986   -566  -3359   -250      0      0      0      0      0
SP     25      1     10   -240    -76    -67   -212    160   -223    -42    -16
SP     30      1    -35   -355    -61    -52   -346    233   -242    -47    -29
SP     35      1    -92   -541    -37     38   -460    304   -226    -66    -37
SP     40      1     -4   -698     46    290   -713    350   -312   -110    -78
SP     45      1    137   -260   -117    150   -543    686   -271   -157   -132
SP     50      1    125   -490   -231    316   -743    649     18   -159   -264
SP     55      1    142   -781   -220    414   -368    222    235    -84   -167
SP     60      1    106  -1023   -101    728   -226   -145    334    -12    -59
SP     65      1   -317  -1126    531    250     24   -658    924    274   -140
SP     70      1   -350   -512    582   -375      0      0      0      0      0
SP     75      1      9    324    350   -237      0      0      0      0      0
SP     80      1    109   1667    603   -290      0      0      0      0      0
SP     85      1    -50  -1062   -237   1865      0      0      0      0      0
SP     90      1   -157    735  -2659    704      0      0      0      0      0
SP     25      2   -576    761      0    619   1379   -144    159     23     72
SP     30      2   -625   1125    215    724   1673   -177    296    110     33
SP     35      2   -996   1332    139   1073   1976    159    510     29   -218
SP     40      2  -1096   1658    201   1197   2355    375    626     -4   -451
SP     45      2   -844   2425    -38   1476   2520    739    310   -118   -581
SP     50      2   -250   2920   -136   1515   1211    270    433    -21   -375
SP     55      2     61   2993    155   1962  -1220    -63    884    243   -370
SP     60      2    501   2825    346   2292  -2378    504    903    320   -384
SP     65      2   -761   2642    197   2929  -4014   -181   3096    556   -313
SP     70      2   1532   3061   -587   1289      0      0      0      0      0
SP     75      2    690   2086   -273    816      0      0      0      0      0
SP     80      2     37   1593  -1908    385      0      0      0      0      0
SP     85      2    -16   1431  -1509   -808      0      0      0      0      0
SP     90      2    630    -60  -3774  -1464      0      0      0      0      0
SP     25      2    101    -41   -138   -184   -170    149   -326    -52    -25
SP     30      2    176    222   -175   -366   -189    403   -530    -89    -28
SP     35      2    235     78   -160   -324   -113    350   -669   -114    -11
SP     40      2    336    135   -135   -339   -282    489   -805   -171    -48
SP     45      2    357    -75    -31     47   -304    555   -629   -155   -153
SP     50      2    432   -416   -181    209   -343    348   -537   -223    -72
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SP	55	2	194	-486	-338	478	-662	580	-44	-165	-175
SP	60	2	386	-762	83	642	-665	799	-83	-164	-277
SP	65	2	-72	-321	337	-42	-515	51	123	52	-114
SP	70	2	-471	-453	575	2	0	0	0	0	0
SP	75	2	113	156	597	-55	0	0	0	0	0
SP	80	2	293	1331	-320	-76	0	0	0	0	0
SP	85	2	576	-841	-1548	1420	0	0	0	0	0
SP	90	2	-446	1008	-2070	-1156	0	0	0	0	0
SP	25	3	-327	312	23	274	1498	194	-167	-32	28
SP	30	3	-522	274	415	676	1906	320	285	114	-69
SP	35	3	-580	211	535	887	2146	459	612	15	-215
SP	40	3	-256	173	108	1070	2035	538	472	-83	-433
SP	45	3	420	375	-291	1092	1676	232	286	-135	-210
SP	50	3	1029	852	-115	964	515	500	208	-82	-217
SP	55	3	1670	865	-401	952	-112	260	80	39	-82
SP	60	3	1550	544	218	1108	-693	-154	682	240	-141
SP	65	3	96	271	769	1527	-865	-490	2872	852	-46
SP	70	3	1418	2048	-33	-300	0	0	0	0	0
SP	75	3	269	1289	804	-434	0	0	0	0	0
SP	80	3	-71	1299	474	-409	0	0	0	0	0
SP	85	3	209	467	276	-540	0	0	0	0	0
SP	90	3	1088	-155	-4063	-761	0	0	0	0	0
SP	25	3	90	-56	-94	-100	-81	27	-189	-20	-1
SP	30	3	56	-130	-126	-78	-188	87	-190	-33	-32
SP	35	3	129	-238	-62	-92	-264	-7	-243	-37	-2
SP	40	3	128	-197	-73	-23	-320	-38	-257	-53	-33
SP	45	3	127	-276	-16	138	-495	112	-59	-39	-156
SP	50	3	169	-208	175	63	-121	-94	93	-55	-62
SP	55	3	257	-79	-399	85	-182	297	55	-119	-162
SP	60	3	216	-49	-34	259	-292	-58	381	37	-17
SP	63	3	126	422	220	-359	-705	371	-49	-67	-105
SP	70	3	-288	80	-22	-187	0	0	0	0	0
SP	75	3	-238	530	-135	408	0	0	0	0	0
SP	80	3	162	1723	-518	-777	0	0	0	0	0
SP	85	3	1130	-427	-1869	431	0	0	0	0	0
SP	90	3	-304	430	-2055	200	0	0	0	0	0
SP	25	4	-459	-592	112	322	1273	10	234	30	117
SP	30	4	-319	-819	472	499	1488	121	533	95	-50
SP	35	4	14	-1099	449	473	1576	177	551	-42	-17
SP	40	4	599	-1216	250	98	1190	249	397	-110	-17
SP	45	4	1314	-1392	-96	-213	820	115	138	-192	136
SP	50	4	1637	-1969	-73	-198	-92	-94	334	-108	170
SP	55	4	2596	-1601	-364	-1082	331	-343	-438	-121	345
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SP	70	4	1634	-2286	-31	140	0	0	0	0	0
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SP	80	4	-169	-2090	-40	756	0	0	0	0	0
SP	85	4	334	52	-982	-1153	0	0	0	0	0
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SP	25	4	-10	-73	-55	-22	-181	-182	57	14	10
SP	30	4	-44	213	-31	-116	-206	-151	40	-2	73
SP	35	4	41	78	124	-120	-231	-309	-34	17	114
SP	40	4	8	296	127	-231	-304	-270	-53	11	130

SP	45	4	15	27	301	10	-516	-580	252	77	117
SP	50	4	358	336	203	-369	-187	-687	-103	-45	254
SP	55	4	475	388	-23	-307	-157	-287	-165	-107	171
SP	60	4	140	70	0	-148	-194	-396	356	-6	142
SP	65	4	387	503	447	-536	272	150	-23	-56	-14
SP	70	4	16	704	181	-504	0	0	0	0	0
SP	75	4	-88	679	269	-775	0	0	0	0	0
SP	80	4	139	1645	-278	-1611	0	0	0	0	0
SP	85	4	1084	-32	-1414	-66	0	0	0	0	0
SP	90	4	234	149	-2049	-472	0	0	0	0	0
SP	25	5	-461	-827	-193	21	1236	46	115	-87	120
SP	30	5	-405	-1138	201	-89	1062	167	435	-31	-43
SP	35	5	-83	-1761	207	-266	1067	-47	548	-81	134
SP	40	5	505	-2029	246	-892	211	-135	569	-47	270
SP	45	5	820	-2363	-1	-1575	-64	-223	440	-147	428
SP	50	5	1257	-3345	153	-1889	135	-538	459	-87	439
SP	55	5	2076	-2684	-104	-3002	369	-366	-829	-409	788
SP	60	5	2429	-4467	-650	-1679	446	404	-1180	-326	402
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SP	30	5	-46	301	-74	-95	-232	-117	21	3	42
SP	35	5	70	178	55	-50	-230	-234	-108	-19	38
SP	40	5	98	261	197	-78	-137	-317	-168	-8	62
SP	45	5	220	212	206	-170	-429	-538	-53	-22	80
SP	50	5	269	354	-189	-206	-550	-447	-90	-139	184
SP	55	5	168	831	-170	-581	-596	-344	170	-102	187
SP	60	5	213	962	-103	-587	-737	-331	108	-57	209
SP	65	5	289	1171	290	-673	-573	194	-203	-172	7
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SP	30	6	-198	-2625	221	134	1958	137	217	61	-261
SP	35	6	66	-3324	271	-292	1993	-209	316	38	36
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SP	65	6	2527	-6108	334	-2552	887	469	-1042	-110	445
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SP	25	6	-57	412	-111	-94	-364	-26	-18	-34	40
SP	30	6	-192	836	35	-246	-656	-201	15	-5	66

59	85	10	334	-52	-982	1153	0	0	0	0	0
59	90	10	900	-438	-3888	1663	0	0	0	0	0
59	25	10	2	-6	-39	60	-84	148	54	14	-8
59	30	10	12	-66	-15	30	8	175	-34	-20	-58
59	35	10	18	58	96	34	-57	337	-30	10	-94
59	40	10	59	-89	97	82	-163	351	-145	-14	-107
59	45	10	179	140	312	-52	-356	629	5	24	-122
59	50	10	450	-9	276	178	-176	849	-218	-59	-276
59	55	10	679	-380	14	321	40	425	-357	-131	-270
59	60	10	323	-351	-5	301	49	361	157	-55	-99
59	65	10	85	109	510	172	-322	-17	297	-9	2
59	70	10	-68	-36	300	154	0	0	0	0	0
59	75	10	-35	589	151	117	0	0	0	0	0
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59	85	10	1084	32	-1414	66	0	0	0	0	0
59	90	10	234	-149	-2049	472	0	0	0	0	0
59	25	11	-481	648	-167	131	1300	-212	186	-51	-32
59	30	11	-408	1089	158	137	1413	-370	464	-20	114
59	35	11	-109	1610	282	374	1268	-244	629	-4	95
59	40	11	519	2112	268	853	508	-84	530	6	-56
59	45	11	880	2554	33	1340	256	96	461	-55	-155
59	50	11	1000	3016	273	1903	-60	250	765	71	-186
59	55	11	973	2377	-120	2930	-871	316	554	-64	-583
59	60	11	661	2208	-111	2959	-1655	280	502	-56	-728
59	65	11	-539	2535	783	2808	-1888	-286	2335	559	-363
59	70	11	321	2900	87	1592	0	0	0	0	0
59	75	11	-486	2952	676	1088	0	0	0	0	0
59	80	11	-302	1562	179	1170	0	0	0	0	0
59	85	11	719	676	-992	420	0	0	0	0	0
59	90	11	901	278	-2890	-1279	0	0	0	0	0
59	25	11	2	-102	-83	-57	-146	61	-24	-16	-5
59	30	11	21	-179	-65	13	-197	146	-85	-9	-36
59	35	11	116	-66	32	-76	-287	296	-249	-48	-48
59	40	11	182	-144	174	-117	-272	413	-386	-56	-59
59	45	11	275	5	160	-50	-644	643	-273	-73	-84
59	50	11	315	-218	-223	61	-524	523	-281	-186	-199
59	55	11	210	-655	-112	436	-579	481	61	-124	-180
59	60	11	381	-781	88	500	-658	494	76	-35	-88
59	65	11	-178	-161	461	81	-1029	231	316	-68	-75
59	70	11	-119	-240	422	374	0	0	0	0	0
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59	30	12	-391	2297	148	44	1631	-321	440	105	282
59	35	12	-190	2904	231	530	1481	-34	648	126	54
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59	60	12	-492	2533	7	3708	-1961	477	835	97	-993
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SP	45	6	246	864	148	-699	-914	-791	-206	-143	278
SP	50	6	384	337	-14	-370	-561	-785	-116	-143	250
SP	55	6	333	388	-103	-316	-249	-480	107	-46	261
SP	60	6	282	780	-290	-888	-500	-499	326	-32	246
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SP	25	7	-505	-1126	67	-458	1185	-176	-182	-58	-20
SP	30	7	-470	-1820	187	-476	1450	-282	-214	-13	-35
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SP	45	7	-1023	-3505	-561	-1244	2744	-831	-599	-370	755
SP	50	7	-769	-4327	-227	-1226	2755	-630	-660	-281	832
SP	55	7	358	-4608	-523	-1668	1009	-1045	-1133	-159	837
SP	60	7	1613	-3266	-525	-3314	-440	-1038	-2134	-342	1225
SP	65	7	2712	-6106	-124	-2458	1206	1016	-1677	37	217
SP	70	7	1877	-6369	-331	-1201	0	0	0	0	0
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SP	80	7	662	-5700	233	1133	0	0	0	0	0
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SP	30	7	-109	625	0	-199	-454	-157	-41	-3	68
SP	35	7	-37	502	8	-68	-476	-336	-230	-64	80
SP	40	7	-57	889	64	-446	-809	-313	-165	-81	99
SP	45	7	-46	929	-17	-522	-841	-568	120	-68	156
SP	50	7	4	712	-125	-432	-608	-566	299	-81	189
SP	55	7	-95	1052	-110	-616	-516	-237	568	-13	135
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SP	65	7	-121	-1178	912	966	1939	301	1394	547	-73
SP	70	7	-433	379	357	310	0	0	0	0	0
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SP	30	8	-505	-1429	98	-575	1529	11	17	-4	-82
SP	35	8	-764	-1731	108	-833	2151	-403	158	-107	242
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SP	85	8	-16	-1431	-1589	888	0	0	0	0	0
SP	90	8	630	60	-3774	1464	0	0	0	0	0

SP	25	8	83	127	-103	116	-187	-85	-277	-32	11
SP	30	8	196	-164	-67	205	74	-318	-364	-35	40
SP	35	8	264	-160	-2	258	127	-281	-525	-51	-7
SP	40	8	352	-65	33	209	42	-370	-600	-88	21
SP	45	8	358	247	35	-305	5	-428	-473	-102	93
SP	50	8	371	553	-148	-322	-461	-298	-382	-191	-20
SP	55	8	74	722	-201	-616	-506	-412	201	-74	131
SP	60	8	202	722	229	-622	-636	-614	212	-73	267
SP	65	8	-9	946	476	-356	-307	83	132	92	91
SP	70	8	-581	768	486	-311	0	0	0	0	0
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SP	80	8	-150	-277	-35	-867	0	0	0	0	0
SP	85	8	576	841	-1549	-1420	0	0	0	0	0
SP	90	8	-446	-1008	-2070	1156	0	0	0	0	0
SP	25	9	-269	-356	27	-243	1470	-207	-255	-54	-35
SP	30	9	-405	-511	409	-570	1975	-468	88	42	58
SP	35	9	-559	-561	546	-677	2290	-734	434	-76	321
SP	40	9	-119	-499	228	-926	2151	-755	241	-155	443
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SP	55	9	2083	-1673	-427	-471	-212	-318	-355	-94	89
SP	60	9	2545	-1784	-167	-455	30	188	-566	-86	70
SP	65	9	2982	-3117	508	145	2456	-226	-273	354	136
SP	70	9	1774	-3800	-109	1306	0	0	0	0	0
SP	75	9	295	-4635	715	2044	0	0	0	0	0
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SP	85	9	209	-467	276	540	0	0	0	0	0
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SP	25	9	80	101	-85	58	-101	2	-168	-12	-6
SP	30	9	83	131	-122	5	-51	-66	-174	-31	21
SP	35	9	164	199	-27	30	-69	31	-238	-29	-20
SP	40	9	164	180	-55	-44	-82	83	-260	-53	-19
SP	45	9	175	96	-57	-47	-143	-148	-70	-41	76
SP	50	9	73	387	-251	-183	-158	116	182	-66	57
SP	55	9	123	260	-246	-224	-258	-281	324	-37	167
SP	60	9	217	-290	44	-104	186	226	467	87	-82
SP	65	9	9	731	268	-314	-684	152	171	5	8
SP	70	9	-363	590	-31	-302	0	0	0	0	0
SP	75	9	-458	427	-51	-1171	0	0	0	0	0
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SP	85	9	1130	427	-1869	-431	0	0	0	0	0
SP	90	9	-304	-430	-2055	-200	0	0	0	0	0
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SP	30	10	-381	690	360	-380	1334	-390	485	17	134
SP	35	10	-189	836	352	-244	1362	-571	665	-77	262
SP	40	10	448	1119	240	43	727	-511	558	-93	146
SP	45	10	1179	1153	-73	290	62	-438	365	-118	37
SP	50	10	1433	1438	-56	492	-669	-290	636	-10	-64
SP	55	10	1098	1051	-332	1338	-880	126	463	68	-302
SP	60	10	1041	376	209	1752	-1305	-36	606	215	-502
SP	65	10	1295	1441	423	1174	-226	-742	1498	481	-110
SP	70	10	712	-130	-424	1418	0	0	0	0	0
SP	75	10	-782	1499	296	89	0	0	0	0	0
SP	80	10	-991	198	15	1168	0	0	0	0	0

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9P     75     12    -84   3674    -23   1982     0     0     0     0     0
9P     80     12    -85   2077   -160   1227     0     0     0     0     0
9P     85     12    939   1013  -1067   -124     0     0     0     0     0
9P     90     12    672   -204  -3358  -1253     0     0     0     0     0
9P     25     12      8   -250   -112    -23  -196    46  -105   -42   -23
9P     30     12    -74   -412     19    -37  -348   239  -102   -42     4
9P     35     12    -70   -665    134    220  -607   454  -167   -73   -56
9P     40     12   -112   -873    139    432  -796   710  -204  -135  -168
9P     45     12    315   -546    -12    473  -925   928  -451  -241  -278
9P     50     12    538   -184   -124    211  -468   911  -484  -259  -299
9P     55     12    450   -404    -18    284   -33   524  -118  -113  -313
9P     60     12    345   -749   -328    881  -265   535   142   -74  -283
9P     65     12    -58  -1017    -31    812  -191   540   529   -27  -407
9P     70     12   -194   -186    563   -300     0     0     0     0     0
9P     75     12   -260    645    351   -250     0     0     0     0     0
9P     80     12   -345   1191    409     12     0     0     0     0     0
9P     85     12   -101  -1061   -624   1611     0     0     0     0     0
9P     90     12   -475   1188  -2589  -1459     0     0     0     0     0

----- END OF FILE WRITTEN -----
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APPENDIX C

SAMPLE INPUT AND OUTPUT FOR THE GRAM PROGRAM

Input to GRAM is as follows:

(All input data cards are in free field format.)

CARD 1

INITIAL HEIGHT - Height of starting position, km

INITIAL LATITUDE - Latitude of starting position (degrees, southern latitudes negative)

INITIAL WEST LONGITUDE - West longitude of starting position (degrees, 0 to 360 degrees, or east longitudes negative)

F10.7 - Solar 10.7 cm radio noise flux (10^{-22} watts/m^2) at time of calculations. Use zero if height does not go over 90 km. Use 230 for design applications or consult Aerospace Environment Division (AED) of Marshall Space Flight Center (MSFC) for monthly predictions.

MEAN F10.7 - 81 day mean solar 10.7 cm flux. Use zero if height does not go over 90 km. Use 230 for design applications or consult AED, MSFC for monthly predictions.

AP - Geomagnetic index a_p. Use zero if height does not go over 90 km. Use 20.3 for design steady state conditions, or 400 for maximum conditions, or consult AED, MSFC.

DATE - Date for starting time of calculations (month, date, two digit year). Use month 13 for annual reference period.

GREENWICH TIME - Time for starting position (hours, minutes, seconds). Use time corresponding to local time - 0900 for design steady state, or 1400 maximum conditions.

LAT INCREMENT - Latitude displacement (degrees) between successive positions (new lat = old lat + lat increment). Use zero if trajectory positions are to be read in.

WEST LON INCREMENT - West longitude displacement (degrees) between successive positions (new long = old lon + lon increment). Use zero if trajectory positions are to be read in.

HEIGHT INCREMENT - Height decrease (km) between successive positions (new height = old height - height increment). Normal profiles are generated downward. If an upward generated profile id desired set height increment negative.

CARD 1

MAXIMUM NUMBER OF POSITIONS - Number of positions to be computed, not including initial position. Use zero if trajectory positions are to be read in.

TIME INCREMENT - Time displacement (seconds) between successive positions for automatically generated profiles (new time = old time + time increment)

TRAJECTORY OPTION - 0 for linear profile generated automatically internal to the program, or value equal to unit number (e.g. 5 for card input) for a trajectory with each position to read in.

OUTPUT OPTION - 0 for no non-print output of atmospheric parameter values, or value equal to unit number to get non-print output.

MIN. GEOSTROPH. LAT. - Lowest latitude (magnitude) for which geostrophic winds are to be used in 4-D (0-25 km) and Jacchia (above 90 km) height segments. Otherwise, interpolation is used to fill in winds. In middle heights (25-90 km), the spherical harmonic model is used at all latitudes.

CARD 2

GROVES INPUT UNIT - Unit number for tape containing Groves and stationary perturbations (SCIDAT tape in Appendix A). Use any available unit number.

RANDOM INPUT UNIT - Unit number of file from which random perturbation data are to be read. If same as Groves input unit, these are read from SCIDAT tape. If card input, use 5.

QBO INPUT UNIT - Unit number of file from which QBO parameters are to be read. If same as Groves input unit, these are read from SCIDAT tape. If card input, use 5.

4-D INPUT UNIT - Unit number for 4-D input data tape. Use any available unit number.

RANDOM OPTION - 1 means compute random perturbation output, 2 means do not compute random perturbation output.

QBO OPTION - 1 means compute QBO output, 2 means do not compute QBO output.

FIRST RANDOM NUMBER - Initial number for random number generator used to compute random perturbations (can be any odd positive integer). Use 1 for standard design applications.

NMC READ OPTION - 0 means read NMC grid data from SCIDAT tape, otherwise these data are read from cards.

4-D, P, D, T, SCRATCH UNIT - Unit number for scratch file for 4-D grid profiles required in computations. Use any available unit number. This normally is a temporary drum file.

CARD 2 (cont'd.)	NMC GRID POINTS SCRATCH UNIT -	Unit number for scratch file to store NMC grid point data. Use any available unit number. This normally is a temporary drum file.
CARD 3 (OPTIONAL)*	INITIAL PL, DL, TL, PS, DS, TS -	Initial values of large scale and small scale random relative pressure, density, and temperature perturbations, percent. Use zeros for standard design applications.
	INITIAL UL, VL, US, VS -	Initial values of large scale and small scale random wind components, m/s. Use zeros for standard design applications.

* - Include card 3 only if random option = 1.

TRAJECTORY INPUT -	Use only if linear profile is not to be generated automatically. Each record has time (seconds), height (km), latitude (degrees), and west longitude (degrees).
TRAJECTORY BACKUP RECORD -	Only if trajectory input is used. Same form as a trajectory position but with any negative height value.

The trajectory input records are optional, in free field format. If included, use as many records (e.g. cards), as necessary.

Input for the following sample output listing is as follows:

CARD1: 92.0, 28.45, 80.53, .0, .0, .0, 1, 1, 75, 0, 0, 0, .0, .0, 2., 47, 0, 0, 0, 20,

CARD2: 3, 3, 3, 4, 1, 1, 1, 0, 12, 13

CARD3: 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.,

A SUMMARY OF THE ORGANIZATION OF AN INPUT DATA DECK IS AS FOLLOWS

Initial Data

Card 1, as described at the beginning of this Appendix

Card 2, as described at the beginning of this Appendix

Card 3, optional, included only if random option = 1

NMC Grid Data

Optional. Include as card input only if this is not to be read from the SCIDAT data tape.

Random Perturbation Data

Optional. Include as card input only if the random input unit is 5 and these data are not to be read from the SCIDAT data tape or some other input file. Do not include if random option = 2.

QBO Parameters

Optional. Include as card input only if the QBO input unit is 5 and these data are not to be read from the SCIDAT data tape or some other file. Do not include if QBO option = 2.

Trajectory Position Data and Backup Card

Optional. Include if trajectory, rather than linear profile generated by the program is to be evaluated, and if trajectory option is 5. Trajectory data is on other file if trajectory unit is not 0 or 5.

More Data of the Same Kind (Starting with Initial Data, Card 1)

If additional trajectories or profiles are to be evaluated, the data may be input one set immediately after the other. The program is actually more efficient for such multiple runs if the month remains the same. This is because as long as the month remains the same the SCIDAT data tape read can be avoided for each subsequent data set.

OUTPUT TO GRAM IS AS FOLLOWS

JULIAN DATE - Computed from input date, set equal to zero for month 13 (annual average)

INITIAL STANDARD DEVIATIONS IN P, D, T, U, V FOR LARGE SCALE AND SMALL SCALE - Computed for initial position on input data

HEIGHT, LAT, LON, TIME	Position and time where atmospheric parameters are evaluated
UNPERTURBED PRESSURE DENSITY, TEMPERATURE AND GEOSTROPHIC WIND (monthly mean values)	Computed from Jacchia, 4-D, or Groves - plus - stationary perturbations, depending on height.
TOTAL PRESSURE, DENSITY, TEMPERATURE, AND WIND	Monthly means plus random perturbations and QBO perturbations
THERMAL WIND SHEAR	From thermal wind equations using finite differences of Jacchia, 4-D, or Groves - plus - stationary perturbations, depending on height.
MEAN VERTICAL WIND	From mean isentropic surface slopes
PERTURBATION VALUES	Stationary perturbations, QBO perturbations and amplitudes, and random perturbations and magnitudes for the small scale (S), large scale (L), and total (T) perturbations. Perturbations are those which are added to monthly means to produce total results output.

Following is a listing of sample output from the GRAM program. Initial lines of output are merely listings of the input data for easy reference. These listings are provided to indicate formats and kinds of input and output data. For a listing of the input cards for these sample outputs, see earlier in the Appendix.

```
1 ****** GLOBAL REFERENCE ATMOSPHERE - MOD 3 ******

  INITIAL HEIGHT =   92.00 KM           INITIAL LAT =  28.45 DEG              INITIAL WEST LON =  80.53 DEG
  F10.7 =     0.00                      MEAN F10.7 =    0.00                  AP =     0.00
  DATE =  1/ 1/75                       GREENWICH TIME =  0: 0: 0
  LAT INCREMENT =   0.00 DEG            WEST LON INCREMENT =   0.00 DEG       HEIGHT INCREMENT =    2.00 KM
  MAXIMUM NUMBER OF POSITIONS =   47    TIME INCREMENT =    0 SEC
  TRAJECTORY OPTION =    0              OUTPUT OPTION =  0                    MIN GEOSTROPH LAT =  10.0

  GROVES INPUT UNIT =  3                RANDOM INPUT UNIT =  3                QBO INPUT UNIT =  3
  4-D INPUT UNIT =  4                   RANDOM OPTION =  1                    QBO OPTION =  1
  FIRST RANDOM NUMBER =      1
  NMC READ OPTION =  0                  4-D P,D,T DATA SCRATCH UNIT = 12
  NMC GRID POINTS SCRATCH UNIT = 13     JULIAN DATE = 2442414.0

  INITIAL P,D,T =   0.00 %     0.00 %     0.00 %           SIGMA P,D,T =  11.13 %   11.06 %    6.58 %
  INITIAL U,V =    0.00 M/S      0.00 M/S                  SIGMA U,V =   47.48 M/S     93.93 M/S          LARGE SCALE

  INITIAL P,D,T =   0.00 %     0.00 %     0.00 %           SIGMA P,D,T =   7.53 %   11.89 %    7.81 %
  INITIAL U,V =    0.00 M/S      0.00 M/S                  SIGMA U,V =   31.35 M/S     62.02 M/S          SMALL SCALE

  INITIAL UBL,VBL = -10.39 % -16.73 %                      INITIAL UDS,VDS = -10.71 %  -9.15 %


  ** PERCENT DEVIATIONS FROM 1962 US STANDARD ATMOSPHERE APPEAR BELOW PRESSURE, DENSITY AND TEMPERATURE VALUES  **


                              UNPERTURBED (MONTHLY MEAN)          MEAN PLUS PERTURBATIONS        THERMAL
                          --------------------------------  --------------------------------    WIND      PERTURBATION VALUES
HEIGHT  LAT   WEST  PRES.     DENS.    TEMP  GEOSTROPH.  PRES.     DENS.    TEMP     TOTAL      SHEAR
 (KM)         LON   (NT/      (KG/     (DEG  WIND (M/S)  (NT/      (KG/     (DEG  WIND (M/S)  (M/S/KM) --------------------------
TIME   (DEG) (DEG)  M**2)     M**3)    KEL-  ----------  M**2)     M**3)    KEL-  ----------  -------- P    D    T    U    V   W
(SEC)                                  VIN)   E-W   N-S                     VIN)   E-W   N-S  E-W  N-S (%)  (%)  (%)  M/S  M/S CM/S

 90.00  28.45  80.53 .199E+00 .367E-05 189.    0.    4. .230E+00 .390E-05 207.  -30.   66.  -.8  -.4                          -.06
   0                  21.0%    15.8%   4.5%                40.1%    23.0%  14.3%                    7.9  7.8   .1           SP
                                                                                                    0.0  0.0  0.0   0.    0. QBO
                                                                                                    0.0  0.0  0.0   0.    0. MAG
                                                                                                    9.4  2.6  6.7  -4.    7. RANS
                                                                                                    7.7 11.8  8.2  30.   62. SIGS
                                                                                                    6.3  3.6  2.7 -26.   54. RANL
                                                                                                   11.1 11.4  7.0  47.   97. SIGL
                                                                                                   15.7  6.3  9.4 -30.   62. RANT
                                                                                                   13.5 16.4 10.8  56.  115. SIGT

 88.00  28.45  80.53 .281E+00 .513E-05 191.    7.    7. .331E+00 .556E-05 209.   13.   60. -3.3 -1.2                          -.09
   0                  18.5%    12.0%   5.9%                39.4%    21.3%  15.6%                    7.7  7.3   .4           SP
                                                                                                    -.1  -.1  -.0  -0.    0. QBO
                                                                                                     .2   .1   .0   0.    0. MAG
                                                                                                    7.6  -.5  8.1  14.   25. RANS
                                                                                                    7.3 10.0  7.1  26.   52. SIGS
                                                                                                   10.1  9.1  1.1  -8.   28. RANL
                                                                                                   10.4 10.0  6.2  41.   82. SIGL
                                                                                                   17.7  8.5  9.2   6.   53. RANT
```

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                                                                                                   12.7 14.1  9.4  48.  97. SIGT

86.00  28.45  80.53 .398E+00 .716E-05  194.   14.    9. .455E+00 .747E-05  213.   22.    5. -3.3 -1.2                            -.16
  0                 16.0%     8.2%    7.4%                32.7%    12.9%   18.0%                          7.5  6.8   .7            SP
                                                                                                   -.1  -.2  -.0  -1.   0. GMO
                                                                                                    .4   .2   .1   1.   0. MAG
                                                                                                   3.6 -2.0  5.6  22. -13. RAMS
                                                                                                   6.9  7.8  5.9  28.  39. SIGS
                                                                                                  10.9  6.6  4.4 -13.   9. RAML
                                                                                                   9.6  8.1  5.2  33.  64. SIGL
                                                                                                  14.5  4.6  9.9   9.  -4. RAMT
                                                                                                  11.8 11.3  7.9  39.  75. SIGT

84.00  28.45  80.53 .560E+00 .996E-05  196.   18.   10. .637E+00 .104E-04  214.    5.    5.  -.9   .6                            -.25
  0                 12.9%     4.1%    8.7%                28.5%     8.8%   18.6%                          7.3  6.4  1.0            SP
                                                                                                   -.1  -.4  -.0  -1.   0. GMO
                                                                                                    .6   .4   .1   1.   0. MAG
                                                                                                   6.4  1.1  5.3  28.  -1. RAMS
                                                                                                   6.5  6.5  5.1  17.  30. SIGS
                                                                                                   7.5  3.7  3.8 -40.  -4. RAML
                                                                                                   8.9  6.9  4.5  29.  50. SIGL
                                                                                                  14.0  4.8  9.1 -12.  -5. RAMT
                                                                                                  11.0  9.5  6.8  34.  58. SIGT

82.00  28.45  80.53 .782E+00 .138E-04  198.   20.    9. .868E+00 .146E-04  208.   -3.   -9.  -.9   .6                            -.28
  0                  9.1%     -.4%    9.8%                21.1%     5.3%   15.2%                          6.9  5.8  1.1            SP
                                                                                                   -.1  -.4  -.0  -1.   0. GMO
                                                                                                    .8   .5   .2   1.   0. MAG
                                                                                                  10.6  4.7  5.9  19.   0. RAMS
                                                                                                   6.1  6.2  4.7  17.  26. SIGS
                                                                                                    .5  1.4  -.8 -40. -18. RAML
                                                                                                   8.2  6.9  4.3  29.  45. SIGL
                                                                                                  11.1  6.1  5.0 -21. -18. RAMT
                                                                                                  10.2  9.3  6.4  33.  53. SIGT

80.00  28.45  80.53 .109E+01 .191E-04  200.   21.    7. .120E+01 .207E-04  202.  -14.   -2.  -.9   .6                            -.31
  0                  5.3%    -4.7%   10.8%                15.8%     3.3%   12.0%                          6.5  5.2  1.3            SP
                                                                                                   -.0  -.5  -.0  -1.   0. GMO
                                                                                                   1.0   .6   .2   2.   0. MAG
                                                                                                   6.8  4.5  2.3   3.   3. RAMS
                                                                                                   5.6  6.0  4.4  16.  23. SIGS
                                                                                                   3.2  4.5 -1.3 -37. -13. RAML
                                                                                                   7.4  6.9  4.0  29.  40. SIGL
                                                                                                  10.0  9.0  1.1 -35. -10. RAMT
                                                                                                   9.3  9.1  5.9  33.  46. SIGT

78.00  28.45  80.53 .152E+01 .262E-04  203.   28.    4. .163E+01 .279E-04  203.    2.  -28. -3.1  1.5                            -.36
  0                  2.2%    -4.8%    7.7%                 9.7%     1.3%    7.9%                          6.1  4.7  1.4            SP
                                                                                                    .0  -.6  -.0  -0.   0. GMO
                                                                                                   1.2   .7   .2   2.   0. MAG
                                                                                                   3.2  4.1  -.9   1.  -1. RAMS
                                                                                                   5.2  5.9  4.6  17.  21. SIGS
                                                                                                   4.1  2.9  1.1 -26. -32. RAML
                                                                                                   6.8  7.0  4.3  31.  39. SIGL
                                                                                                   7.3  7.1   .2 -25. -33. RAWT
                                                                                                   8.6  9.2  6.3  35.  45. SIGT

 76.00  28.45  80.53 .212E+01 .359E-04  206.   34.    2. .225E+01 .382E-04  204.   11.  -44. -3.1  1.5                       -.37
   0                      .7%    -3.8%  4.7%                 7.0%     2.2%  3.9%                   5.7  4.1  1.6            SP
                                                                                                    .2  -.6  -.0   0.   0. OBO
                                                                                                   1.4   .9   .3   2.   0. MAG
                                                                                                  -2.4   .5 -2.9   2.  -3. RAWS
                                                                                                   4.8  5.8  4.8  17.  20. SIGS
                                                                                                   8.5  6.4  2.1 -25. -43. RAWL
                                                                                                   6.2  7.2  4.5  33.  38. SIGL
                                                                                                   6.1  6.9  -.8 -23. -46. RAWT
                                                                                                   7.8  9.2  6.6  37.  43. SIGT

 74.00  28.45  80.53 .293E+01 .490E-04  208.   38.   -2. .289E+01 .527E-04  188.   -2.  -23. -1.1  1.7                       -.28
   0                     -.3%    -2.2%  2.0%                -1.8%     5.0% -8.0%                   5.4  4.3  1.1            SP
                                                                                                    .3  -.5   .0   1.   0. OBO
                                                                                                   1.6  1.0   .3   3.   0. MAG
                                                                                                  -7.4  1.6 -9.0  -6.   4. RAWS
                                                                                                   4.6  5.6  4.6  18.  18. SIGS
                                                                                                   5.5  6.4  -.9 -35. -26. RAWL
                                                                                                   5.8  7.2  4.5  24.  34. SIGL
                                                                                                  -1.9  8.0 -9.9 -41. -21. RAWT
                                                                                                   7.4  9.1  6.4  38.  39. SIGT

 72.00  28.45  80.53 .401E+01 .659E-04  212.   40.   -5. .441E+01 .760E-04  199.    1.    9. -1.1  1.7                       -.14
   0                     -.9%    -1.0%   .1%                 8.9%    14.1% -6.3%                   5.2  4.4   .7            SP
                                                                                                    .5  -.4   .0   1.   1. OBO
                                                                                                   1.8  1.2   .4   3.   1. MAG
                                                                                                  -1.9  4.2 -6.0  -8.  15. RAWS
                                                                                                   4.6  5.3  3.8  19.  15. SIGS
                                                                                                  11.2 11.6  -.4 -32.  -2. RAWL
                                                                                                   5.9  7.2  4.1  35.  28. SIGL
                                                                                                   9.3 15.7 -6.4 -41.  13. RAWT
                                                                                                   7.4  8.9  5.6  40.  32. SIGT

 70.00  28.45  80.53 .550E+01 .887E-04  216.   43.   -8. .586E+01 .974E-04  207.  -14.   -5. -1.1  1.7                       -.00
   0                     -.4%     1.3% -1.7%                 6.1%    11.3% -6.0%                   5.0  4.6   .3            SP
                                                                                                    .7  -.3   .1   2.   1. OBO
                                                                                                   2.0  1.3   .4   3.   1. MAG
                                                                                                   -.8  1.9 -2.7 -16.   4. RAWS
                                                                                                   4.6  5.1  3.0  20.  11. SIGS
                                                                                                   6.6  8.3 -1.7 -43.  -1. RAWL
                                                                                                   5.9  7.1  3.5  36.  19. SIGL
                                                                                                   5.8 10.1 -4.4 -59.   3. RAWT
                                                                                                   7.4  8.7  4.6  41.  22. SIGT

 68.00  28.45  80.53 .742E+01 .116E-03  222.   48.   -6. .737E+01 .122E-03  207.   30.  -29. -2.9 -1.1                       -.39
   0                     -.4%     1.9% -2.2%                -1.0%     7.1% -8.8%                   4.7  4.8  -.1            SP
                                                                                                   1.0  -.1   .1   3.   1. OBO
                                                                                                   2.2  1.4   .4   3.   1. MAG
                                                                                                  -4.7  -.8 -3.9  -7.   1. RAWS
                                                                                                   4.5  4.9  2.6  20.  12. SIGS
                                                                                                   3.1  6.0 -2.9 -14. -25. RAWL
```

```
                                                                                                 5.8  7.1  3.4  34.  20. SIGL
                                                                                                -1.6  5.2 -6.8 -22. -24. RAMT
                                                                                                 7.4  8.6  4.3  40.  23. SIGT

66.00  28.45  80.53 .100E+02 .152E-03  230.   54.   -4. .105E+02 .141E-03  225.  28.  -21. -2.9 -1.1                      -.33
  0                      .8%     3.2%  -2.3%                  5.6%     9.1%  -4.6%                   4.8  4.8  -.1           SP
                                                                                                 1.2   .1   .1   4.   1. GBO
                                                                                                 2.4  1.5   .5   4.   1. MAG
                                                                                                -4.7 -3.4 -1.2  -3.   8. RAMS
                                                                                                 4.4  4.6  2.3  20.  13. SIGS
                                                                                                 8.4  9.6 -1.2 -27. -26. RAML
                                                                                                 5.8  7.1  3.3  32.  20. SIGL
                                                                                                 3.7  6.2 -2.5 -30. -18. RAMT
                                                                                                 7.3  8.5  4.0  38.  24. SIGT

64.00  28.45  80.53 .133E+02 .196E-03  237.   52.   -1. .136E+02 .202E-03  233.  -3.  -21.  4.7 -1.8                      .01
  0                     1.5%     4.1%  -2.5%                  3.6%     7.4%  -4.4%                   4.8  4.9  -.1           SP
                                                                                                 1.6   .6   .2   4.   1. GBO
                                                                                                 2.6  1.6   .5   4.   1. MAG
                                                                                                -2.4 -2.1  -.3 -26.  14. RAMS
                                                                                                 4.4  4.5  2.1  19.  14. SIGS
                                                                                                 2.9  4.8 -1.8 -33. -34. RAML
                                                                                                 5.8  6.8  3.1  30.  19. SIGL
                                                                                                  .5  2.6 -2.1 -59. -20. RAMT
                                                                                                 7.2  8.1  3.8  35.  24. SIGT

62.00  28.45  80.53 .175E+02 .250E-03  244.   43.    3. .184E+02 .264E-03  241.  -5.  -19.  4.7 -1.8                      .39
  0                     1.6%     4.6%  -2.8%                  6.4%    10.4%  -4.2%                   4.8  4.9  -.1           SP
                                                                                                 2.1  1.1   .3   4.   1. GBO
                                                                                                 2.8  1.8   .6   4.   1. MAG
                                                                                                -1.7 -1.2  -.5 -27.  13. RAMS
                                                                                                 4.3  4.3  2.2  18.  13. SIGS
                                                                                                 4.3  5.5 -1.2 -25. -35. RAML
                                                                                                 5.7  6.3  2.8  27.  17. SIGL
                                                                                                 2.6  4.3 -1.7 -52. -22. RAMT
                                                                                                 7.1  7.6  3.6  32.  21. SIGT

60.00  28.45  80.53 .230E+02 .320E-03  251.   33.    6. .229E+02 .323E-03  246.  -9.   -7.  4.7 -1.8                      .74
  0                     2.4%     4.5%  -1.9%                  1.8%     5.6%  -3.9%                   4.8  4.9  -.1           SP
                                                                                                 2.5  1.6   .3   4.   0. GBO
                                                                                                 3.0  1.9   .6   5.   1. MAG
                                                                                                -6.1 -3.6 -2.5 -17.   9. RAMS
                                                                                                 4.2  4.1  2.2  16.  13. SIGS
                                                                                                 3.1  3.0   .1 -31. -23. RAML
                                                                                                 5.7  5.7  2.5  24.  14. SIGL
                                                                                                -3.0  -.6 -2.4 -47. -14. RAMT
                                                                                                 7.0  7.0  3.3  28.  19. SIGT

58.00  28.45  80.53 .299E+02 .404E-03  257.   29.    6. .298E+02 .417E-03  249. -36.    3.  2.6   .2                      .58
  0                     2.6%     3.9%  -1.1%                  2.3%     6.7%  -4.2%                   4.7  4.6   .1           SP
                                                                                                 2.3  1.8   .3   4.   1. GBO
                                                                                                 2.8  2.1   .5   5.   1. MAG
                                                                                                -5.3 -3.1 -2.2 -25.  16. RAMS
                                                                                                 4.1  3.9  2.2  15.  12. SIGS
```

```
                                                                                                   2.8  4.0 -1.2 -43. -20. RAWL
                                                                                                   5.4  5.3  2.3  24.  13. SIGL
                                                                                                  -2.5   .9 -3.5 -68.  -4. RAWT
                                                                                                   6.8  6.6  3.1  28.  18. SIGT

56.00  28.45  80.53 .388E+02 .515E-03  263.   23.     6. .432E+02 .575E-03  262.  -36.   10.  2.6   .2                  .40
    0                   3.2%     3.6%  -.3%                14.6%    15.5%  -.6%                        4.6  4.3   .3           SP
                                                                                                   2.1  2.0   .2   3.   1. DBD
                                                                                                   2.6  2.3   .4   5.   1. MAG
                                                                                                  -1.0   .4 -1.4 -15.  29. RAWS
                                                                                                   3.9  3.8  2.1  14.  12. SIGS
                                                                                                   9.8  8.9   .9 -48. -26. RAWL
                                                                                                   5.2  4.9  2.1  25.  11. SIGL
                                                                                                   8.8  9.3  -.5 -63.   4. RAWT
                                                                                                   6.5  6.2  2.9  28.  17. SIGT

54.00  28.45  80.53 .501E+02 .652E-03  267.   18.     6. .525E+02 .696E-03  264.  -17.    8.  2.3  -.0                  .30
    0                   3.2%     3.3%  -.0%                 8.3%    10.3% -1.5%                        4.5  4.0   .5           SP
                                                                                                   2.1  2.2   .2   3.   1. DBD
                                                                                                   2.5  2.5   .3   5.   1. MAG
                                                                                                  -2.7  -.3 -2.4  -9.  19. RAWS
                                                                                                   3.8  3.6  2.0  14.  12. SIGS
                                                                                                   5.4  4.6   .8 -29. -17. RAWL
                                                                                                   5.0  4.7  1.9  25.  11. SIGL
                                                                                                   2.7  4.4 -1.6 -38.   2. RAWT
                                                                                                   6.3  5.9  2.7  28.  16. SIGT

52.00  28.45  80.53 .640E+02 .824E-03  271.   14.     6. .711E+02 .920E-03  271.  -18.   17.  2.3  -.0                  .15
    0                   2.8%     2.9%   .2%                14.3%    14.9%   .0%                        4.4  3.7   .7           SP
                                                                                                   2.2  2.4   .1   3.   0. DBD
                                                                                                   2.5  2.6   .3   5.   1. MAG
                                                                                                  -1.1  1.8 -2.8  -8.  20. RAWS
                                                                                                   3.6  3.5  1.8  13.  12. SIGS
                                                                                                   9.8  7.2  2.6 -26.  -9. RAWL
                                                                                                   4.9  4.6  1.7  26.  11. SIGL
                                                                                                   8.8  9.0  -.2 -34.  11. RAWT
                                                                                                   6.1  5.7  2.5  29.  16. SIGT

50.00  28.45  80.53 .811E+02 .103E-02  275.    9.     6. .848E+02 .111E-02  268.  -27.   14.  2.3  -.0                  .05
    0                   1.7%      .5%  1.5%                 6.3%     8.1% -1.1%                        3.5  2.6   .9           SP
                                                                                                   2.3  2.6   .1   2.  -0. DBD
                                                                                                   2.6  2.6   .2   4.   2. MAG
                                                                                                  -4.5   .9 -5.4 -23.  15. RAWS
                                                                                                   3.5  3.4  1.6  12.  11. SIGS
                                                                                                   6.6  3.9  2.7 -15.  -6. RAWL
                                                                                                   4.7  4.5  1.6  26.  11. SIGL
                                                                                                   2.1  4.8 -2.7 -18.   9. RAWT
                                                                                                   5.9  5.6  2.3  29.  16. SIGT

48.00  28.45  80.53 .103E+03 .132E-02  273.    8.     4. .106E+03 .135E-02  274.  -12.    3.   .5   .6                 -.03
    0                   1.1%      .0%  1.0%                 3.5%     2.4%  1.3%                        2.6  1.5  1.0           SP
                                                                                                   2.4  2.5   .3   1.  -0. DBD
                                                                                                   2.5  2.5   .4   4.   1. MAG
                                                                                                  -4.5 -1.3 -3.3  -8.   6. RAWS
```

```
                                                                                       3.3  3.2  1.7  11.   11. SIGS
                                                                                       4.6  1.2  3.3 -13.   -8. RAML
                                                                                       4.6  4.3  1.7  25.   11. SIGL
                                                                                        .0  -.1   .1 -21.   -1. RAMT
                                                                                       5.6  5.4  2.4  28.   15. SIGT

46.00  28.45  80.53 .132E+03 .168E-02  272.   7.   3. .134E+03 .174E-02  268.  -25.   9.  .5  .6                  -.07
  0                     .3%   -2.0%    2.0%              1.7%     1.3%    .5%          1.6   .3  1.2             SP
                                                                                       2.4  2.4   .5  -8.   -1. GRO
                                                                                       2.5  2.4   .7   3.    1. MAG
                                                                                      -3.2  -.5 -2.7  -3.   17. RAMS
                                                                                       3.1  3.0  1.7  11.   10. SIGS
                                                                                       2.2  1.4   .7 -39.  -10. RAML
                                                                                       4.4  4.2  1.8  25.   10. SIGL
                                                                                      -1.6  1.0 -2.0 -41.    7. RAMT
                                                                                       5.4  5.1  2.5  27.   14. SIGT

44.00  28.45  80.53 .168E+03 .216E-02  269.   6.   2. .164E+03 .214E-02  267.  -23.   7.  .3  .7                  -.07
  0                    -.9%   -4.3%    3.1%             -3.1%    -5.2%   2.3%           7  -.8  1.4             SP
                                                                                       2.4  2.1   .7  -1.   -1. GRO
                                                                                       2.4  2.1   .8   3.    1. MAG
                                                                                      -4.5 -2.4 -2.2  -3.   16. RAMS
                                                                                       2.9  2.8  1.8  10.    9. SIGS
                                                                                        .1  -.6   .7 -25.  -10. RAML
                                                                                       4.2  3.9  1.9  24.   10. SIGL
                                                                                      -4.4 -3.0 -1.4 -28.    6. RAMT
                                                                                       5.1  4.8  2.6  26.   13. SIGT

42.00  28.45  80.53 .218E+03 .286E-02  264.   6.   0. .213E+03 .283E-02  262.  -14.   7.  .3  .7                  -.13
  0                   -1.0%   -4.5%    3.3%             -3.1%    -5.4%   2.3%          1.3  -.0  1.3             SP
                                                                                       2.2  1.8   .7  -3.   -1. GRO
                                                                                       2.2  1.8   .8   4.    1. MAG
                                                                                      -8.0 -3.3 -4.7  -4.   11. RAMS
                                                                                       2.7  2.6  1.8   9.    8. SIGS
                                                                                       3.8   .7  3.1 -13.   -3. RAML
                                                                                       4.0  3.5  2.0  22.    9. SIGL
                                                                                      -4.3 -2.6 -1.6 -17.    8. RAMT
                                                                                       4.8  4.3  2.7  24.   12. SIGT

40.00  28.45  80.53 .279E+03 .373E-02  260.   5.  -1. .287E+03 .380E-02  263.  -11.  -2.  .3  .7                  -.05
  0                   -3.0%   -6.7%    3.8%              -.0%    -5.0%   5.1%           .7  -.8  1.4             SP
                                                                                       2.1  1.4   .8  -5.   -2. GRO
                                                                                       2.1  1.4   .8   5.    2. MAG
                                                                                      -2.0 -1.5  -.6   4.    6. RAMS
                                                                                       2.6  2.3  1.8   8.    7. SIGS
                                                                                       2.9  1.8  1.1 -16.   -5. RAML
                                                                                       3.7  3.1  2.1  20.    8. SIGL
                                                                                        .9   .4   .5 -12.    0. RAMT
                                                                                       4.5  3.8  2.0  22.   11. SIGT

38.00  28.45  80.53 .363E+03 .504E-02  252.   6.  -2. .380E+03 .521E-02  254.  -17.   7. -.4  .5                  -.07
  0                   -3.3%   -6.1%    2.9%               .8%    -2.9%   3.9%           .2  -.9  1.1             SP
                                                                                       1.8  1.2   .8  -7.   -1. GRO
                                                                                       1.8  1.2   .8   7.    1. MAG
```

```
                                                                                                   -1.4 -1.5   .0  -0.  10. RAWS
                                                                                                    2.3  2.2  1.9   8.   7. SIGS
                                                                                                    3.8  3.7   .1 -16.   1. RAWL
                                                                                                    3.4  2.9  2.0  19.   8. SIGL
                                                                                                    2.4  2.2   .1 -17.  11. RAWT
                                                                                                    4.2  3.6  2.8  20.  10. SIGT

36.00  28.45  80.53 .477E+03 .681E-02  244.    7.   -3. .510E+03 .700E-02  255.  -15.   -5.  -.4   .5                         -.13
   0                  -4.3%    -6.3%   2.0%                2.4%    -3.5%   6.4%                                -.3 -1.1   .8           SP
                                                                                                    1.6  1.0   .8  -9.  -1. GRD
                                                                                                    1.6  1.0   .9   9.   1. MAG
                                                                                                     .8 -1.8  2.5   2.   0. RAWS
                                                                                                    2.1  2.2  1.9   7.   7. SIGS
                                                                                                    4.5  3.6   .9 -15.  -1. RAWL
                                                                                                    3.1  2.7  1.9  17.   7. SIGL
                                                                                                    5.3  1.8  3.4 -13.  -1. RAWT
                                                                                                    3.8  3.4  2.7  19.  10. SIGT

34.00  28.45  80.53 .628E+03 .921E-02  238.    7.   -4. .657E+03 .949E-02  242.  -19.    5.   .6   .1                         -.18
   0                  -5.3%    -6.9%   1.8%                -.9%    -4.0%   3.7%                                -.8 -1.2   .5           SP
                                                                                                    1.3   .7   .9  -9.  -1. GRD
                                                                                                    1.3   .8   .9  10.   1. MAG
                                                                                                     .3  -.1   .4   6.   9. RAWS
                                                                                                    1.9  2.1  1.8   6.   6. SIGS
                                                                                                    2.9  2.4   .5 -21.   1. RAWL
                                                                                                    2.8  2.5  1.8  16.   7. SIGL
                                                                                                    3.2  2.3   .9 -16.  10. RAWT
                                                                                                    3.4  3.2  2.6  17.   9. SIGT

32.00  28.45  80.53 .833E+03 .129E-01  233.    5.   -4. .813E+03 .124E-01  235.   -3.   -3.   .6   .1                         -.15
   0                  -6.3%    -8.1%   2.2%               -6.2%    -8.3%   2.7%                               -1.2 -1.4   .2           SP
                                                                                                    1.0   .5   .9  -9.  -1. GRD
                                                                                                    1.0   .7   .9  10.   1. MAG
                                                                                                   -1.9  -.9  -.9  10.   3. RAWS
                                                                                                    2.0  1.9  1.8   6.   5. SIGS
                                                                                                     .8   .2   .6  -9.  -2. RAWL
                                                                                                    2.5  2.3  1.7  14.   6. SIGL
                                                                                                   -1.0  -.7  -.3   1.   2. RAWT
                                                                                                    3.1  3.0  2.4  15.   8. SIGT

30.00  28.45  80.53 .110E+04 .169E-01  229.    4.   -4. .114E+04 .169E-01  236.    1.   -8.   .6   .1                         -.11
   0                  -7.8%    -8.4%   1.0%               -5.0%    -8.2%   4.4%                               -1.7 -1.5  -.1           SP
                                                                                                     .8   .2  1.0  -8.  -1. GRD
                                                                                                     .8   .5  1.0  10.   1. MAG
                                                                                                    -.8 -1.2  1.2  10.  -3. RAWS
                                                                                                    1.6  1.8  1.7   5.   4. SIGS
                                                                                                    2.3  1.2  1.1  -4.  -1. RAWL
                                                                                                    2.2  2.1  1.5  12.   4. SIGL
                                                                                                    2.3  -.0  2.3   5.  -4. RAWT
                                                                                                    2.7  2.8  2.3  13.   6. SIGT

28.00  28.45  80.53 .151E+04 .225E-01  225.    4.   -3. .151E+04 .228E-01  231.    6.   -8.   .2  -.1                         -.0
   0                  -6.4%    -6.2%    .1%               -6.8%    -9.1%   3.1%                                0.0  0.0  0.0           SP
                                                                                                     .5  -.2   .9  -6.  -1. GRD
```

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                                                                                                  .6   .6  1.0   9.   1. MAG
                                                                                                 -.8 -2.7  1.9   3.  -3. RAWS
                                                                                                 1.5  1.6  1.5   4.   3. SIGS
                                                                                                 -.0  -.2   .1   6.  -0. RAWL
                                                                                                 2.0  1.9  1.4  11.   4. SIGL
                                                                                                 -.9 -2.9  2.1   9.  -3. RAWT
                                                                                                 2.5  2.4  2.1  12.   5. SIGT

26.00  28.45  80.53 .207E+04 .328E-01  220.   3.  -3. .208E+04 .316E-01  230.   5.   0.  .2  -.1                       -.07
  0                   -5.3%    -4.3%  -1.0%                -4.8%    -7.7%  3.3%                     0.0  0.0  0.0            SP
                                                                                                  .2  -.6   .9  -5.   -. UBO
                                                                                                  .4   .7   .9   8.    . MAG
                                                                                                  .8 -1.5  2.4   7.   2. RAWS
                                                                                                 1.3  1.3  1.3   4.   3. SIGS
                                                                                                 -.5 -1.5  1.0  -0.   2. RAWL
                                                                                                 1.8  1.6  1.3  10.   3. SIGL
                                                                                                  .3 -3.0  3.3   7.   4. RAWT
                                                                                                 2.2  2.0  1.9  10.   4. SIGT

24.00  28.45  80.53 .284E+04 .457E-01  216.   4.  -2. .285E+04 .449E-01  221.   1.  -2. 1.1  .3                       -.05
  0                   -4.6%    -2.6%  -1.9%                -4.2%    -4.4%   .3%                     0.0  0.0  0.0            SP
                                                                                                  .1  -.7   .8  -3.  -1. UBO
                                                                                                  .3   .7   .9   7.   1. MAG
                                                                                                  .2  -.2   .3   0.   2. RAWS
                                                                                                  .5   .6   .6   3.   3. SIGS
                                                                                                  .1 -1.0  1.2  -0.  -1. RAWL
                                                                                                  .6   .7   .6   8.   3. SIGL
                                                                                                  .3 -1.2  1.5  -0.   1. RAWT
                                                                                                  .8   .9   .8   9.   4. SIGT

22.00  28.45  80.53 .391E+04 .643E-01  212.   6.  -1. .389E+04 .636E-01  213.   5.  -5.  -.1  -.0                       .00
  0                   -3.5%     -.3%  -3.7%                -3.9%    -1.4% -2.5%                     0.0  0.0  0.0            SP
                                                                                                  .1  -.5   .7  -0.  -1. UBO
                                                                                                  .2   .6   .7   6.   1. MAG
                                                                                                  .0  -.2   .2   3.   1. RAWS
                                                                                                  .4   .6   .5   3.   3. SIGS
                                                                                                 -.6  -.4  -.2  -3.  -4. RAWL
                                                                                                  .6   .7   .5   8.   3. SIGL
                                                                                                 -.6  -.5  -.0  -0.  -3. RAWT
                                                                                                  .7  1.0   .8   9.   5. SIGT

20.00  28.45  80.53 .545E+04 .914E-01  207.  16.   3. .546E+04 .916E-01  208.   6.  -3. -1.6  -.3                       -.00
  0                   -1.5%     2.8%  -4.2%                -1.3%     3.0% -4.0%                     0.0  0.0  0.0            SP
                                                                                                  .1  -.3   .6   2.  -0. UBO
                                                                                                  .2   .5   .6   5.   1. MAG
                                                                                                 -.6  -.6  -.0   0.   1. RAWS
                                                                                                  .4   .7   .5   3.   3. SIGS
                                                                                                  .7  1.1  -.4 -12.  -6. RAWL
                                                                                                  .6   .9   .5   8.   4. SIGL
                                                                                                  .1   .5  -.4 -11.  -5. RAWT
                                                                                                  .7  1.1   .8   8.   5. SIGT

18.00  28.45  80.53 .759E+04 .129E+00  205.  19.   4. .759E+04 .128E+00  206.  12.  -0. -3.3  -.4                       -.07
  0                     .3%     6.0%  -5.4%                  .3%     5.6% -5.0%                     0.0  0.0  0.0            SP
```

```
                                                                                                  .1  -.3   .5   2.  -0. GRO
                                                                                                  .2   .4   .5   4.   0. MAG
                                                                                                 -.1  -.5   .3   2.   3. RAWS
                                                                                                  .5   .9   .6   3.   5. SIGS
                                                                                                  .0   .4  -.3 -11.  -8. RAWL
                                                                                                  .6  1.0   .6   9.   5. SIGL
                                                                                                 -.1  -.1  -.0  -9.  -4. RAWT
                                                                                                  .8  1.3   .8   9.   7. SIGT

16.00  28.45  80.53 .107E+05 .183E+00  204.   30.    3. .107E+05 .181E+00  207.   16.  -15. -4.1  -.3                           -.09
   0                    3.5%     9.8%  -5.8%                3.7%     8.7%  -4.6%                     0.0  0.0  0.0            SP
                                                                                                  .1  -.2   .4   2.  -0. GRO
                                                                                                  .1   .3   .4   3.   0. MAG
                                                                                                 -.4 -1.2   .8   2.  -8. RAWS
                                                                                                  .6  1.1   .7   3.   6. SIGS
                                                                                                  .5   .5   .0 -18. -10. RAWL
                                                                                                  .7  1.2   .6  10.   7. SIGL
                                                                                                  .2  -.7   .9 -16. -10. RAWT
                                                                                                  .9  1.6   .9  10.   9. SIGT

14.00  28.45  80.53 .149E+05 .246E+00  210.   37.    4. .148E+05 .244E+00  212.   22.   -6. -1.1  -.1                           -.04
   0                    5.0%     8.1%  -2.9%                4.7%     7.2%  -2.3%                     0.0  0.0  0.0            SP
                                                                                                  .0  -.2   .2   2.  -0. GRO
                                                                                                  .1   .2   .2   2.   0. MAG
                                                                                                 -.8 -1.2   .4  -6.   1. RAWS
                                                                                                  .7  1.1   .7   4.   7. SIGS
                                                                                                  .5   .5   .0 -11. -10. RAWL
                                                                                                  .9  1.3   .7  11.   8. SIGL
                                                                                                 -.3  -.7   .4 -17.  -9. RAWT
                                                                                                 1.1  1.7  1.0  12.  11. SIGT

12.00  28.45  80.53 .205E+05 .328E+00  217.   35.    3. .204E+05 .335E+00  212.   20.  -11.  2.1   .1                            .07
   0                    5.5%     5.2%    .3%                5.2%     7.3%  -2.0%                     0.0  0.0  0.0            SP
                                                                                                  .0  -.1   .1   1.  -0. GRO
                                                                                                  .0   .1   .1   1.   0. MAG
                                                                                                 -.4   .6 -1.0   4.  -8. RAWS
                                                                                                  .7  1.0   .8   4.   8. SIGS
                                                                                                  .1  1.5 -1.3 -20.  -6. RAWL
                                                                                                  .9  1.1   .7  13.   9. SIGL
                                                                                                 -.3  2.1 -2.4 -16. -15. RAWT
                                                                                                 1.1  1.5  1.1  13.  12. SIGT

10.00  28.45  80.53 .278E+05 .421E+00  230.   32.    3. .282E+05 .423E+00  232.   11.   -1.  3.5   .2                            .16
   0                    4.8%     1.8%   3.0%                6.6%     2.4%   4.1%                     0.0  0.0  0.0            SP
                                                                                                 0.0  0.0  0.0   0.   0. GRO
                                                                                                 0.0  0.0  0.0   0.   0. MAG
                                                                                                  .1  -.7   .7  -5.  -4. RAWS
                                                                                                  .7   .9   .8   5.   9. SIGS
                                                                                                 1.6  1.2   .3 -17.  -0. RAWL
                                                                                                  .9  1.0   .8  14.  10. SIGL
                                                                                                 1.7   .6  1.1 -22.  -4  RAWT
                                                                                                 1.1  1.3  1.1  15.  14. SIGT

 8.00  28.45  80.53 .370E+05 .529E+00  244.   26.    3. .367E+05 .526E+00  243.    4.   -9.  3.9   .2                            .46
 0              1.9%     .6%  3.3%              3.1%     .0%  3.0%                          0.0  0.0  0.0           SP
                                                                                            0.0  0.0  0.0   0.    0. GRD
                                                                                            0.0  0.0  0.0   0.    0. MAG
                                                                                            -.3  -.0  -.3  -4.   -2. RAMS
                                                                                             .6   .8   .8   4.    8. SIGS
                                                                                            -.5  -.5   .0 -18.  -10. RAML
                                                                                             .8   .8   .8  12.    9. SIGL
                                                                                            -.8  -.5  -.3 -22.  -13. RAMT
                                                                                            1.0  1.1  1.1  13.   12. SIGT

6.00  28.45  80.53 .486E+05 .654E+00  259.   20.   3. .479E+05 .655E+00  255.   4.  -14.  3.6  .3                      .27
 0              2.9%    -.9%  3.8%              1.5%    -.7%  2.3%                          0.0  0.0  0.0           SP
                                                                                            0.0  0.0  0.0   0.    0. GRD
                                                                                            0.0  0.0  0.0   0.    0. MAG
                                                                                            -.7   .5 -1.3   0.   -9. RAMS
                                                                                             .5   .7   .7   3.    6. SIGS
                                                                                            -.6  -.4  -.2 -16.   -8. RAML
                                                                                             .7   .7   .7  10.    8. SIGL
                                                                                           -1.3   .1 -1.4 -15.  -17. RAMT
                                                                                             .9  1.0  1.0  11.   10. SIGT

4.00  28.45  80.53 .628E+05 .808E+00  271.   12.   3. .631E+05 .808E+00  272.  15.   -2.  3.5  .3                      .28
 0              1.9%   -1.4%  3.3%              2.3%   -1.4%  3.8%                          0.0  0.0  0.0           SP
                                                                                            0.0  0.0  0.0   0.    0. GRD
                                                                                            0.0  0.0  0.0   0.    0. MAG
                                                                                             .2  -.3   .6  -1.   -6. RAMS
                                                                                             .5   .6   .7   3.    5. SIGS
                                                                                             .2   .3  -.1   3.    1. RAML
                                                                                             .6   .7   .7   9.    6. SIGL
                                                                                             .4  -.1   .5   2.   -5. RAMT
                                                                                             .7   .9  1.0   9.    8. SIGT

2.00  28.45  80.53 .804E+05 .996E+00  281.    6.   2. .807E+05 .989E+00  284.   5.    2.  3.5 1.0                     -.00
 0              1.1%   -1.1%  2.2%              1.5%   -1.7%  3.2%                          0.0  0.0  0.0           SP
                                                                                            0.0  0.0  0.0   0.    0. GRD
                                                                                            0.0  0.0  0.0   0.    0. MAG
                                                                                             .2  -.6   .7  -3.   -3. RAMS
                                                                                             .4   .8   .8   2.    4. SIGS
                                                                                             .2  -.1   .3   2.    3. RAML
                                                                                             .5   .8   .8   7.    5. SIGL
                                                                                             .4  -.7  1.0  -1.    0. RAMT
                                                                                             .6  1.1  1.2   7.    7. SIGT

0.00  28.45  80.53 .102E+06 .123E+01  288.   -1.  -1. .102E+06 .124E+01  287.  -4.    4.  5.6 1.4                     -.14
 0               .8%     .7%   .1%               .7%    1.2%  -.5%                          0.0  0.0  0.0           SP
                                                                                            0.0  0.0  0.0   0.    0. GRD
                                                                                            0.0  0.0  0.0   0.    0. MAG
                                                                                            -.3  -.0  -.3   0.    1. RAMS
                                                                                             .3  1.4  1.4   1.    3. SIGS
                                                                                             .3   .6  -.3  -3.    4. RAML
                                                                                             .4  1.4  1.4   5.    4. SIGL
                                                                                            -.1   .5  -.6  -3.    5. RAMT
                                                                                             .5  1.9  2.0   5.    5. SIGT
```

APPENDIX D - GRAM PROGRAM LISTING

Following is a listing of the Global Reference Atmospheric Model (GRAM) - Mod 3. Sequence numbers containing a four character subroutine code and a four digit number appear on the right of the printout.

```
C     FIRST DATA CARD READS INITIAL HEIGHT (KM), INITIAL LATITUDE (DEG)
C        INITIAL LONGITUDE (DEG), F10.7, MEAN F10.7, AP, MONTH, DAY,
C        YEAR (TOTAL YEAR - 1900), GREENWICH HOUR, MINUTES, SECONDS,
C        LATITUDE INCREMENT (DEG), LONGITUDE INCREMENT (DEG),
C        HEIGHT DECREASE (KM), MAXIMUM NUMBER OF POSITIONS (EXCLUDING
C        INITIAL POSITION) TO BE COMPUTED, TIME INCREMENT BETWEEN
C        POSITIONS, TRAJECTORY OPTION, OUTPUT OPTION,MINIMUM GEOSTROPHIC
C         LATITUDE
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI
     .           NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,
     $ MN, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,AP,
     .   IHR,MIN,NMORE,DX,HL,VL,DZ,B,EPS,IOPP,LOOK,IET,GLAT,
     1RP1S,RD1S,RT1S,RU1S,RV1S,SP1S,SD1S,ST1S,SU1S,SV1S,
     2UDS1,VDS1,UDL1,VDL1,UDS2,VDS2,UDL2,VDL2
      COMMON/CHIC/LA(4,4),NB(2),IWSYM,UCOEF(14,9),VCOEF(14,9)
      COMMON/WINCOM/ DUMSTF(17),UPRE,VPRE,DUPRE,DVPRE
 9090 FORMAT('1 ****** GLOBAL REFERENCE ATMOSPHERE - MOD 3 ******'/)
      PI=3.1415927
      FAC=0.017453293
      LOOK=0
      MONTH = 0
      IOPT=0
       H=0.
    5 IF(IOPT.EQ.0.OR.(IOPT.GT.0.AND.H.LT.0.)) GO TO 6
      READ(IOPT,10) IET,H,PHI,THET
10    FORMAT( )
      GO TO 5
    6 MN = MONTH
      NSAME = 0
      READ(5,10,END=90) H1,PHI1,THET1,F10,F10B,AP,MN,IDA ,IYR,IHRO,MINO,
     1 ISECO,DPHI,DTHET,DH,NMAX,INCT,IOPT,IOPP,GLAT
   91 REWIND 4
      WRITE(6,9090)
      IF(ABS(PHI1).LE.90.)GO TO 7
      PHI1=SIGN(180.-ABS(PHI1),PHI1)
      THET1=THET1+180.
      IF(THET1.GT.360.)THET1=THET1-360.
    7 IF(THET1.LT.0.) THET1=THET1+360
      GLAT = ABS(GLAT)
      IF (GLAT.LT. 5.) GLAT =  5.
      IF (GLAT.GE.18.) GLAT = 17.999
      GLATF=GLAT*FAC
      WRITE(6,9010) H1,PHI1,THET1,F10,F10B,AP,MN,IDA ,IYR,IHRO,MINO,
     $ ISECO,DPHI,DTHET,DH,NMAX,INCT,IOPT,IOPP,GLAT
C      SET NSAME TO AVOID SETUP
   15 IF (MN.EQ.MONTH) NSAME = 1
C     LOOKUP ON MULTIPLE PASSES
      MONTH = MN
C      CONVERT LATITUDE TO RADIANS
      PHI1R=PHI1*FAC
C     CONVERT LONGITUDE TO RADIANS
      THET1R=THET1*FAC
C     CONVERT LATITUDE INCREMENT TO RADIANS
      DPHIR=DPHI*FAC
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C     CONVERT LONGITUDE INCREMENT TO RADIANS
      DTHETR=DTHET*FAC
C     READ DATA TAPE TO INITIALISE ARRAYS
      CALL SETUP
      NT = 1
      IF(IOPT.EQ.0) GO TO 18
      READ(IOPT,10) IET,H,PHI,THET
      IF(ABS(PHI).LE.90.) GO TO 16
      PHI = SIGN(180.-ABS(PHI),PHI)
      THET = THET + 180.
   16 IF(THET.LT.0.)THET=THET+360.
      IF(THET.GT.360.) THET = THET - 360.
      PHIR=PHI*FAC
      THETR=THET*FAC
      GO TO 19
   18 H = H1 - DH
C.....DISPLACES POSITION BEFORE EVALUATION OF ATMOSPHERIC PARAMETERS
      IET = INCT
      PHIR=PHI1R+DPHIR
      THETR=THET1R+DTHETR
      IF (ABS(PHIR).LE.PI/2.) GO TO 17
      PHIR = SIGN(PI-ABS(PHIR),PHIR)
      THETR = THETR + PI
17    IF (THETR.GT.2.*PI) THETR = THETR - 2.*PI
      IF (THETR.LT.0.) THETR = THETR + 2.*PI
C       A=EQUATORIAL EARTH RADIUS, B = POLAR EARTH RADIUS
C       EPS= EARTH ECCENTRICITY
   19 A = 6378.160
      B = 6356.7747
      EPS=(1.-(B*B)/(A*A))
C.....COMPUTES RADIUS TO HEIGHT H, AND GRAVITY AT HEIGHT AND
C         LATITUDE PHIR
      CALL RIG
      ISEC=ISEC0+IET
      ISEC=MOD(ISEC,60)
      MIN = MIN0 + IET/60
      IHR = IHR0 + MIN / 60
      MIN = MOD(MIN,60)
C.....COMPUTES P,D,T,U,V AT FIRST POSITION AFTER INITILL POSITION
      IF(H1.LE.30.) LOOK=1
      IF(ABS(PHIR).GT.GLATF) GO TO 195
      PHIS=PHIR
      DPHIS=(PHIR+GLATF)/(2.*GLATF)
      PHIR=GLATF
      CALL SCIMOD(0)
      UP2=UPRE
      VP2=VPRE
      DUP2=DUPRE
      DVP2=DVPRE
      PHIR=-GLATF
      CALL SCIMOD(0)
      UP1=UPRE
      VP1=VPRE
      DUP1=DUPRE
      DVP1=DVPRE
      UPRE=UP1+(UP2-UP1)*DPHIS
      VPRE=VP1+(VP2-VP1)*DPHIS
      DUPRE=DUP1+(DUP2-DUP1)*DPHIS
      DVPRE=DVP1+(DVP2-DVP1)*DPHIS
      PHIR=PHIS
  195 CALL SCIMOD(1)
   20 NT = NT + 1
      IF (IOPT.EQ.0) GO TO 22
      READ(IOPT,10) IET,H,PHI,THET
      IF(H.LT.0.)GO TO 5
      IF(ABS(PHI).LE.90.)GO TO 21
      PHI=SIGN(180.-ABS(PHI),PHI)
      THET=THET+180.
   21 IF(THET.LT.0.)THET=THET+360.
      IF(THET.GT.360.)THET=THET-360.
      PHIR=PHI*FAC
      THETR=THET*FAC
      GO TO 25
C     INCREMENT THE HEIGHT
   22 H = H1 - DH
      IF (H .LT. 0.0) GO TO 5
C     INCREMENT THE LATITUDE
      PHIR=PHIR+DPHIR
C     INCREMENT THE LONGITUDE
      THETR=THETR+DTHETR
C.....READS NEW INPUT IF ABS(LAT) GTR 90 DEG
      IF (ABS(PHIR).LE.PI/2) GO TO 23
      PHIR=SIGN(PI-ABS(PHIR),PHIR)
      THETR=THETR+PI
   23 IF (THETR.GT.2.*PI) THETR = THETR - 2. * PI
      IF (THETR.LT.0.) THETR = THETR + 2. * PI
C      INCREMENT THE TIME
      IET=IET+INCT
   25 MIN=MINO+IET/60
      ISEC=ISECO+IET
      ISEC=MOD(ISEC,60)
      IHR=IHRO+MIN/60
      MIN=MOD(MIN,60)
C     COMPUTE RADIUS AND GRAVITY AT NEW POSITION
      CALL RIG
C     COMPUTE P,D,T,U,V, AT NEW POSITION
      IF(ABS(PHIR).GT.GLATF) GO TO 80
      PHIS=PHIR
      DPHIS=(PHIR+GLATF)/(2.*GLATF)
      PHIR=GLATF
      CALL SCIMOD(0)
      UP2=UPRE
      VP2=VPRE
      DUP2=DUPRE
      DVP2=DVPRE
      PHIR=-GLATF
      CALL SCIMOD(0)
      UP1=UPRE
      VP1=VPRE
      DUP1=DUPRE
      DVP1=DVPRE
      UPRE=UP1+(UP2-UP1)*DPHIS
      VPRE=VP1+(VP2-VP1)*DPHIS
      DUPRE=DUP1+(DUP2-DUP1)*DPHIS
      DVPRE=DVP1+(DVP2-DVP1)*DPHIS
      PHIR=PHIS
80    CALL SCIMOD(1)

C.....READS NEW INPUT IF MMORE = 0 OR MAX POINTS COMPUTED
      IF(MMORE.EQ.0.OR.(IOPT.EQ.0.AND.NT.GE.MMAX)) GO TO 5
C     CYCLE TO NEW POSITION
      GO TO 20
   90 STOP
 9010 FORMAT('  INITIAL HEIGHT = ',F7.2,' KM',T43,'INITIAL LAT = ',
     1F6.2,' DEG',T83,'INITIAL WEST LON = ',F6.2,' DEG',/,'  F10.7 = ',F
     $8.2,
     2T43,'MEAN F10.7 = ',F7.2,T83,'AP = ',F8.2,/,'  DATE = ',I2,'/',I2,
     3'/',I2,T43,'GREENWICH TIME = ',I2,':',I2,':',I2/,'  LAT INCREMENT
     4= ',F6.2,' DEG',T43,'WEST LON INCREMENT = ',F6.2,' DEG',T83,'HEI',
     $'GHT INCR',
     5'EMENT = ',F7.2,' KM',/,'  MAXIMUM NUMBER OF POSITIONS = ',I4,T43,
     6'TIME INCREMENT = ',I4,' SEC',/2X,'TRAJECTORY OPTION = ',I4,
     7T43,'OUTPUT OPTION = ',I2,T83,'MIN GEOSTROPH LAT = ',F5.1,/)
      END
      SUBROUTINE ADJUST
      COMMON/C4/DUM1(32),MG,P(16,26),D(16,26),T(16,26),SP(16,26)
     $,SD(16,26),ST(16,26),DU1,DU2,HS
      COMMON/ADJCOM/A(26,3), B(26), X(26), KOUNT
      DIMENSION PQ(26), QQ(26), UC(26), VC(26), WC(26), U(26), V(26),
     $ W(26)
C     ASSUMPTIONS@
C       HS IS THE SURFACE LEVEL
C       ALL DATA VALUES ABOVE SURFACE LEVEL ARE IN 1 KM INCREMENTS
      E1=0.075
      E2=0.150
      MAXIT=3
      KSMAX=10
      HSJ = HS
      IF (HS.LT.0.) HSJ = 0.
      JJ=INT(HSJ+2.)
      STEST=0.05
      ISS=1
      CONST=28703./980.665
      N=26
      ITER=0
      UC(1)=SQRT(SP(KOUNT,1))
      VC(1)=SQRT(SD(KOUNT,1))
      WC(1)=SQRT(ST(KOUNT,1))
      DO 5 I=JJ,N
      UC(I)=SQRT(SP(KOUNT,I))
      VC(I)=SQRT(SD(KOUNT,I))
    5 WC(I)=SQRT(ST(KOUNT,I))
```

```
      NM=N-1
      NP=N+1
C.....SETS UP QUADRATURE FACTORS
      PQ(1)=500.*(FLOAT(INT(HSJ+1.))-HS)/(CONST*T(KOUNT,1))
      QQ(1)=500.*(FLOAT(INT(HSJ+1.))-HS)/(CONST*T(KOUNT,JJ))
      DO 15 I=JJ,NM
      IP=I+1
      PQ(I)=500./(CONST*T(KOUNT,I))
   15 QQ(I)=500./(CONST*T(KOUNT,IP))
      GO TO 58
   12 NM=N-1
      NP=N+1
      DO 14 I=1,26
      U(I)=UC(I)*UC(I)
      V(I)=VC(I)*VC(I)
      W(I)=WC(I)*WC(I)
   14 CONTINUE
C.....INITIALIZE A(I,J)
      DO 20 I=1,26
      DO 20 J=1,3
   20 A(I,J)=0.
C.....SETS UP COEFFICIENTS
      I2=0
      DO 35 I=1,NM
      IF(I.GT.1.AND.I.LT.JJ) GO TO 35
      AW=1./SP(KOUNT,I)
      BW=1./SD(KOUNT,I)
      CW=1./ST(KOUNT,I)
      IM=I-1
      IF(I.EQ.JJ) IM=1
      IP=I+1
      IF (I.EQ.1) IP=JJ
      I2=I2+1
      AW1=1./SP(KOUNT,IP)
      BW1=1./SD(KOUNT,IP)
      CW1=1./ST(KOUNT,IP)
      IF(I.EQ.1) GO TO 25
      A(I2,1)=-(1.-QQ(IM))*(1.+PQ(I))/AW+(1./BW+1./CW)*PQ(I)*QQ(IM)
   25 A(I2,2)=((1.-QQ(I))**2)/AW1+((1.+PQ(I))**2)/AW+(1./BW+1./CW)
     $ *(PQ(I)**2)+(1./BW1+1./CW1)*QQ(I)**2
      IF(I.EQ.NM) GO TO 30
      A(I2,3)=-(1.-QQ(I))*(1.+PQ(IP))/AW1+(1./BW1+1./CW1)*
     $ PQ(IP)*QQ(IP)
   30 B(I2)=U(IP)-U(I)-(U(I)-V(I)+W(I))*PQ(I)-(U(IP)-V(IP)+W(IP))*QQ(I)
   35 CONTINUE
      CALL DIAGEQ(I2)
C.....FINDS CORRECTIONS
      AW=1./SP(KOUNT,1)
      BW=1./SD(KOUNT,1)
      CW=1./ST(KOUNT,1)
      UC(1)=SQRT(U(1)+X(1)*(1.+PQ(1))/AW)
      VC(1)=SQRT(V(1)-X(1)*PQ(1)/BW)
      WC(1)=SQRT(W(1)+X(1)*PQ(1)/CW)
      AW=1./SP(KOUNT,N)
```

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```
      BW=1./SD(KOUNT,N)                                                 ADJU  83
      CW=1./ST(KOUNT,N)                                                 ADJU  84
      UC(N)=SQRT(U(N)-X(I2)*(1.-QQ(NN))/AW)                             ADJU  85
      VC(N)=SQRT(V(N)-X(I2)*QQ(NN)/BW)                                  ADJU  86
      WC(N)=SQRT(W(N)+X(I2)*QQ(NN)/CW)                                  ADJU  87
      I2=1                                                              ADJU  88
      DO 40 I=JJ,NN                                                     ADJU  89
      I2=I2+1                                                           ADJU  90
      I2M=I2-1                                                          ADJU  91
      AW=1./SP(KOUNT,I)                                                 ADJU  92
      BW=1./SD(KOUNT,I)                                                 ADJU  93
      CW=1./ST(KOUNT,I)                                                 ADJU  94
      IM=I-1                                                            ADJU  95
      IF(I.EQ.JJ)IM=1                                                   ADJU  96
      UC(I)=ABS(U(I)        +(-X(I2M)*(1.-QQ(IM))+X(I2)*(1.+PQ(I)))/AW) ADJU  97
      UC(I)=SQRT(UC(I))                                                 ADJU  98
      VC(I)=ABS(V(I)        -(X(I2M)*QQ(IM)+X(I2)*PQ(I))/BW)            ADJU  99
      VC(I)=SQRT(VC(I))                                                 ADJU 100
      WC(I)=ABS(W(I)        +(X(I2M)*QQ(IM)+X(I2)*PQ(I))/CW)            ADJU 101
   40 WC(I)=SQRT(WC(I))                                                 ADJU 102
C.....GETS ADJUSTED VALUES                                               ADJU 103
C.....   ADJUSTS ON TRIANGLE INEQUALITIES                               ADJU 104
   58 K=0                                                               ADJU 105
      DO 68 I=1,N                                                       ADJU 106
      IF(I.GT.1.AND.I.LT.JJ) GO TO 68                                   ADJU 107
      AU=UC(I)                                                          ADJU 108
      AV=VC(I)                                                          ADJU 109
      AM=WC(I)                                                          ADJU 110
      AMAX=AMAX1(AU,AV,AM)                                              ADJU 111
      EE=E1*AMAX                                                        ADJU 112
      EF=E2*AMAX                                                        ADJU 113
      AW=SP(KOUNT,I)                                                    ADJU 114
      BW=SD(KOUNT,I)                                                    ADJU 115
      CW=ST(KOUNT,I)                                                    ADJU 116
      COR=AU+AV-AM-EE                                                   ADJU 117
      DIV=AW+BW+CW                                                      ADJU 118
      IF(COR.GT.0.) GO TO 60                                            ADJU 119
      COR=(AU+AV-AM-EF)/DIV                                             ADJU 120
      AU=AU-COR*AW                                                      ADJU 121
      AV=AV-COR*BW                                                      ADJU 122
      AM=AM+COR*CW                                                      ADJU 123
      GO TO 64                                                          ADJU 124
   60 COR=AU-AV+AM-EE                                                   ADJU 125
      IF(COR.GT.0.) GO TO 62                                            ADJU 126
      COR=(AU-AV+AM-EF)/DIV                                             ADJU 127
      AU=AU-COR*AW                                                      ADJU 128
      AV=AV+COR*BW                                                      ADJU 129
      AM=AM-COR*CW                                                      ADJU 130
      GO TO 64                                                          ADJU 131
   62 COR=-AU+AV+AM-EE                                                  ADJU 132
      IF(COR.GT.0.) GO TO 66                                            ADJU 133
      COR=(-AU+AV+AM-EF)/DIV                                            ADJU 134
      AU=AU+COR*AW                                                      ADJU 135
      AV=AV-COR*BW                                                      ADJU 136
      AM=AM-COR*CW
   64 K=K+1
   66 UC(I)=AU
      VC(I)=AV
      WC(I)=AW
   68 CONTINUE
      KMAX=K
  100 IF((ITER.EQ.0).OR.(KMAX.NE.0)) GO TO 110
      GO TO 112
  110 ITER=ITER+1
      IF(ITER.LE.MAXIT) GO TO 12
  112 IF (ISS.NE.1) GO TO 999
  114 ITER=1
      ISS=2
      VTA=VC(1)
      WTA=WC(1)
      DO 120 I=JJ,NM
      IN=I-1
      IF(I.EQ.JJ)IN=1
      VTB=VC(I)
      WTB=WC(I)
      VC(I)=(VC(I+1)+2.*VTB+VTA)*0.25
      WC(I)=(WC(I+1)+2.*WTB+WTA)*0.25
      VTA=VTB
      WTA=WTB
  120 CONTINUE
      GO TO 12
C.....CALCULATE THE CORRECTED VARIANCES
  999 DO 1010 I=1,N
      IF(I.GT.1.AND.I.LT.JJ) GO TO 1010
      SP(KOUNT,I)=UC(I)**2
      SD(KOUNT,I)=VC(I)**2
      ST(KOUNT,I)=WC(I)**2
 1010 CONTINUE
      RETURN
      END
      SUBROUTINE CHECK
      COMMON/CHK/P(4,4,3),RHO(4,4,3),NO(2)
      COMMON/WINCON/DGH,FCORY,DX5,DY5
      COMMON/CHIC/LA(16),NB(2),IWSYM,UCOEF(14,9),VCOEF(14,9)
      NB(1) = 0
      NB(2) = 0
      CALL GROUP
      NS=0
      NR=1
      IF(NO(1).EQ.0.AND.NO(2).EQ.0) GO TO 1000
      DO 640 KL=1,2
      IF (NO(KL).EQ.0) GO TO 640
  450 CONTINUE
      NNR=4*NR
      IF(NO(KL).LE.NNR) GO TO 500
      NR=NR+1
      GO TO 450
  500 CONTINUE
```

```
      I1=NR                                                             CHEC  19
      J1=ND(KL)-(NR-1)*4                                                CHEC  20
      SH1 = 6.                                                          CHEC  21
      SH2 = 6.                                                          CHEC  22
      DP = P(I1,J1,2) - P(I1,J1,1)                                      CHEC  23
      IF (DP) 510,520,510                                               CHEC  24
  510 SH1 = ABS(P(I1,J1,2)/DP)                                          CHEC  25
  520 DP = P(I1,J1,2) - P(I1,J1,3)                                      CHEC  26
      IF (DP) 530,540,530                                               CHEC  27
  530 SH2 = ABS(P(I1,J1,2)/DP)                                          CHEC  28
  540 IF(SH1.LT.4.0.OR.SH2.LT.4.0) GO TO 640                            CHEC  29
      IF(SH1.GT.9.0.OR.SH2.GT.9.0) GO TO 640                            CHEC  30
      NR=1                                                              CHEC  31
      NS=NS+1                                                           CHEC  32
  640 CONTINUE                                                          CHEC  33
      RETURN                                                            CHEC  34
 1000 INSYN = '*'                                                       CHEC  35
      RETURN                                                            CHEC  36
      END                                                               CHEC  37
      SUBROUTINE CORLAT(A,B,C,D,E,F,G,H,AI,AJ,AK,SP1,SP2,SD1,SD2,ST1,   CORL   1
     1 ST2,SU1,SU2,SV1,SV2,UD1,UD2,VD1,VD2,RD,RT,RV)                    CORL   2
      IF(SD1*ST1*SD2*ST2.GT.0.) GO TO 5                                 CORL   3
C.....DEFAULT VALUES AVOID DIVISION BY ZERO                              CORL   4
      IF(SD1.LE.0.) SD1=0.001                                           CORL   5
      IF(ST1.LE.0.) ST1=0.001                                           CORL   6
      IF(SD2.LE.0.) SD2=0.001                                           CORL   7
      IF(ST2.LE.0.) ST2=0.001                                           CORL   8
      IF(RD.LE.0.) RD = .00001                                          CORL   9
      IF(RT.LE.0.) RT = .00001                                          CORL  10
      IF(RV.LE.0.) RV = .00001                                          CORL  11
 5    CONTINUE                                                          CORL  12
      IF(ABS(TD1).LE.0.) TD1 = 0.001                                    CORL  13
      IF (ABS(UD1).LE.0.) UD1 = 0.001                                   CORL  14
      IF (ABS(VD1).LE.0.) VD1 = 0.001                                   CORL  15
      IF (ABS(SU1).LE.0.) SU1 = 0.001                                   CORL  16
      IF (ABS(SV1).LE.0.) SV1 = 0.001                                   CORL  17
      IF (ABS(UD1).GE.1.) UD1 = 0.99*UD1/ABS(UD1)                       CORL  18
      IF (ABS(VD1).GE.1.) VD1 = 0.99*VD1/ABS(VD1)                       CORL  19
      A=RD*SD2/SD1                                                      CORL  20
      B=SD2*SQRT(1-RD*RD)                                               CORL  21
      TD2=(SP2*SP2-SD2*SD2-ST2*ST2)/(2*SD2*ST2)                         CORL  22
      TD1=(SP1*SP1-SD1*SD1-ST1*ST1)/(2*SD1*ST1)                         CORL  23
      IF(ABS(TD2).GE.1.0) TD2=0.99*TD2/ABS(TD2)                         CORL  24
      IF(ABS(TD1).GE.1.0) TD1=0.99*TD1/ABS(TD1)                         CORL  25
      C=(ST2/ST1)*(RT-RD*TD2*TD1)/(1-TD1*TD1*RD*RD)                     CORL  26
      D=(RT*ST2*ST1-C*ST1*ST1)/(A*TD1*SD1*ST1)                          CORL  27
      E=     ST2*ST2-C*C*ST1*ST1-D*D*SD2*SD2-2*C*D*RD*TD1*ST1*SD2       CORL  28
      IF(E.GE.0.) GO TO 10                                              CORL  29
      E=0.                                                              CORL  30
   10 E=SQRT(E)                                                         CORL  31
      F=(SU2/SU1)*(RV-RD*UD2*UD1)/(1-RD*RD*UD1*UD1)                     CORL  32
      G=(RV*SU2-F*SU1)/(RD*UD1*SD2)                                     CORL  33
      H=     SU2*SU2-F*F*SU1*SU1-G*G*SD2*SD2-2*F*G*RD*UD1*SD2*SU1       CORL  34
      IF(H.GE.0.) GO TO 15                                              CORL  35
      H=0.                                                              CORL  36
   15 H=SQRT(H)                                                         CORL  37
      AI=(SV2/SV1)*(RV-RD*VD2*VD1)/(1-RD*RD*VD1*VD1)                    CORL  38
      AJ=(RV*SV2-AI*SV1)/(RD*VD1*SD2)                                   CORL  39
      AK=      SV2*SV2-AI*AI*SV1*SV1-AJ*AJ*SD2*SD2-2*AI*AJ*RD*VD1*SD2*SV1CORL  40
      IF(AK.GE.0.) GO TO 25                                             CORL  41
      AK=0.                                                             CORL  42
   25 AK=SQRT(AK)                                                       CORL  43
      RETURN                                                            CORL  44
      END                                                               CORL  45
      SUBROUTINE DIAGEQ(N)                                              DIAG   1
C     A(I,J)=DIAG. TERMS, I=ROW NO., J=DIAG. NO.                        DIAG   2
C     B(I)=RIGHT SIDE TERMS                                             DIAG   3
C     N=NO. OF ROWS                                                     DIAG   4
C     K=NO. OF BORDER DIAGONALS, M=K+1=INDES OF PRIN. DIAG              DIAG   5
C             2KM=TOTAL NO. OF DIAGS.                                   DIAG   6
C     X(I)=SOLUTION                                                     DIAG   7
      COMMON/ADJCOM/A(26,3), B(26), X(26)                               DIAG   8
      K = 1                                                             DIAG   9
      M=K+1                                                             DIAG  10
      DO 30 L=1,N                                                       DIAG  11
      ALM=A(L,M)                                                        DIAG  12
      A(L,M)=1.                                                         DIAG  13
      IF(L.EQ.N) GO TO 15                                               DIAG  14
      I2=MINO(K,N-L)                                                    DIAG  15
      DO 10 I=1,I2                                                      DIAG  16
      MPI=M+I                                                           DIAG  17
   10 A(L,MPI)=A(L,MPI)/ALM                                             DIAG  18
   15 B(L)=B(L)/ALM                                                     DIAG  19
      IF(L.EQ.N) GO TO 30                                               DIAG  20
      DO 25 I=1,I2                                                      DIAG  21
      LPI=L+I                                                           DIAG  22
      FACT=A(LPI,M-I)                                                   DIAG  23
      DO 20 J=1,I2                                                      DIAG  24
      MJI=M+J-I                                                         DIAG  25
   20 A(LPI,MJI)=A(LPI,MJI)-A(L,M+J)*FACT                               DIAG  26
   25 B(LPI)=B(LPI)-B(L)*FACT                                           DIAG  27
   30 CONTINUE                                                          DIAG  28
      X(N)=B(N)                                                         DIAG  29
      NM1=N-1                                                           DIAG  30
      DO 50 L=1,NM1                                                     DIAG  31
      NML=N-L                                                           DIAG  32
      SUM=0.                                                            DIAG  33
      I2=MINO(K,L)                                                      DIAG  34
      DO 40 I=1,I2                                                      DIAG  35
   40 SUM=SUM+A(NML,M+I)*X(NML+I)                                       DIAG  36
   50 X(NML)=B(NML)-SUM                                                 DIAG  37
      RETURN                                                            DIAG  38
      END                                                               DIAG  39
      SUBROUTINE FAIR (PG, DG, TG, PJ, DJ, TJ, IH, P, D, T,             FAIR   1
     $ DPYG, DPXJ, DPYJ, DPX, DPY,      DTYG, DTXJ, DTYJ, DTX, DTY)     FAIR   2
C.....FAIRS BETWEEN GROVES AND JACCHIA VALUES 90 LE HEIGHT LE 115 KM    FAIR   3
      DIMENSION CZ(6)                                                   FAIR   4
C.....FAIRING VALUES                                                    FAIR   5
```

```
      DATA CZ /1.0,0.9045085,0.6545085,0.3454915,0.0954915,0.0/
C     HEIGHT INDEX
      I =(IH - 85)/5
C     GROVES FAIRING COEFFICIENT
      CZI = CZ(I)
C     JACCHIA FAIRING COEFFICIENT
      SZI = 1.0 - CZI
C     FAIRED TEMPERATURE
      T = TG*CZI + TJ*SZI
C     FAIRED PRESSURE
      P = EXP(ALOG(PG)*CZI + ALOG(PJ)*SZI)
C     FAIRED DENSITY
      D = EXP(ALOG(DG)*CZI + ALOG(DJ)*SZI)
      DPX = DPXJ
C     DP/DY FOR GEOSTROPHIC WINDS
      DPY=DPYG*CZI+DPYJ*SZI
      DTX = DTXJ
C      DT/DY FOR THERMAL WINDS
      DTY = DTYG * CZI + DTYJ * SZI
      RETURN
      END
      SUBROUTINE GEN4D
C.....GENERATES NG = 9 OR 16 4D PROFILES P,D,T AND SIGMAS SP,SD,ST AT
C        GRID OF LATITUDES AND LONGITUDES GLAT,GLON. CURRENT LATITUDE,
C        LONGITUDE=CLAT,CLON. PREVIOUS LATITUDE,LONGITUDE=PLAT,PLON.
      COMMON/C4/GLAT(16),GLON(16),NG,P(16,26),D(16,26),T(16,26),
     $ SP(16,26),SD(16,26),ST(16,26),PLON,CLON,HS
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,MMCOP,DDD,XMJD,PLAT,CLAT,
     $ NSAME,RP1,RD1,RT1,SP1,SD1,ST1,RU1,RV1,SU1,SV1,
     $ MN,IDA,IYR,H1,PHI1R,THET1R,GZ,RI,Z,PHIR,THETR,F10,F10B,AP,
     $ IHR,MIN,NMORE,DX,HL,VL,DZ,B,EPS,IOPP,LOOK,DUMMY(20)
      COMMON/PDTCON/IU4,MONTH,IOPR,PG(18,19),TG(18,19),DG(18,19),
     1      FSP(8,10,12),DSP(8,10,12),TSP(8,10,12)
     2,PAQ(17,5),DAQ(17,5),TAQ(17,5),
     3PDQ(17,5),DDQ(17,5),TDQ(17,5),PR(20,10),DR(20,10),TR(20,10),
     4UAQ(17,5),VAQ(17,5),UDQ(17,5),VDQ(17,5),UR(25,10),VR(25,10),
     5PQ,DQ,TQ,UQ,VQ,PQA,DQA,TQA,UA,VA,IOPQ
     * ,PLP(25,10),DLP(25,10),TLP(25,10),ULP(25,10),VLP(25,10),UDL(25,
     * 10),VDL(25,10),UDS(25,10),VDS(25,10)
      COMMON/ADJCOM/DUM(130),KOUNT
      COMMON/IPRTP/ IPRT
      IF(NSAME.EQ.1) RETURN
      IPRT=0
      LOOK=0
      F = 0.017453293
      NG = 16
      DX = PLON - CLON
C.....LONGITUDE DISPLACEMENT FROM PREVIOUS TO CURRENT POSITION
      DY = CLAT - PLAT
C.....LATITUDE DISPLACEMENT FROM PREVIOUS TO CURRENT POSITION
      IF (DY) 20,10,20
 10   IF (DX) 15,12,15
 12   K = 0
      GO TO 40
```

```
   15 THETA = 180. + SIGN(90.,DX)
      GO TO 30
   20 THETA = ATAN(DX/DY)/F
      IF (DY.GT.0.) THETA = THETA + 180.
      IF (THETA.LT.0.) THETA = THETA + 360.
C.....THETA = AZIMUTH ANGLE OF TRAJECTORY, USED TO ORIENT LAT-LON GRID
   30 K = INT((THETA + 67.5)/45.)
C     INDEX USED IN COMPUTED GO TO FOR 110 THRU 180
      IF (K.GT.8) K=K-8
C     NORTH POLAR GRID
      IF (CLAT.GT.75.0.AND.K.GE.3.AND.K.LE.7)GO TO 200
C     SOUTH POLAR GRID
      IF (CLAT.LT.-75.0.AND.(K.GE.7.OR.K.LE.3))GO TO 200
C.....INITIAL ESTIMATE OF REFERENCE LATITUDE (LOWER LEFT GRID POINT)
 40   LATO = 5*INT(CLAT/5.)
      IF (CLAT.LT.0.) LATO = LATO - 5
C.....INITIAL ESTIMATE OF REFERENCE LONGITUDE (LOWER LEFT GRID POINT)
      LONO=5*INT(CLON/5.)
C.....ADJUSTS LATO,LONO ACCORDING TO DIRECTION OF TRAJECTORY AZIMUTH
      IF (K.GT.0) GO TO 100
      LATO = LATO - 5
      LONO= LONO + 10
      GO TO 190
 100  GO TO (110,120,130,140,150,160,170,180),K
  110 LATO = LATO-10
      LONO = LONO + 10
      GO TO 190
  120 LATO = LATO-10
      LONO = LONO+15
      GO TO 190
  130 LATO = LATO-5
      LONO = LONO+15
      GO TO 190
  140 LONO = LONO+15
      GO TO 190
  150 LONO = LONO+10
      GO TO 190
  160 LONO = LONO+5
      GO TO 190
  170 LATO = LATO-5
      LONO = LONO+5
      GO TO 190
  180 LATO = LATO-10
      LONO = LONO+5
  190 IF (LONO.GT.360) LONO = LONO - 360
      DLI=1.25
      IF(ABS(CLAT).GE.18) GO TO 192
      DLI=3.0
      LATO=-18
  192 DO 195 I=1,4
      I12 = I+12
      DO 195 J=I,I12,4
      GLAT(J) = LATO + 1.25*(J-I)
C.....LATITUDE, LONGITUDE GRID AT 5 DEGREE INTERVALS
```

```
  195 GLON(J) = LON0 - 5. * (I - 1)
      GO TO 400
C     POLAR GRID
  200 NG = 9
      DO 210 J=1,8
C.....POLAR GRID LATITUDES 1-8 = +75 (N) OR -75 (N)
      GLAT(J) = SIGN(75.,CLAT)
C.....POLAR GRID LONGITUDES 1-8 AT 45 DEG INTERVALS
  210 GLON(J) = 45.*(J-1)
C.....POLAR GRID LATITUDE 9 = POLE +90 OR -90
      GLAT(9) = SIGN(90.,CLAT)
C.....POLAR GRID LONGITUDE 9 = 0
      GLON(9) = 0.
C.....GENERATES 16 PROFILES (OR 9 PROFILES FOR POLAR GRID)
  400 CALL GRID4D
      DO 600 I=1,NG
      CHECK=P(I,26)*D(I,26)*T(I,26)*SP(I,26)*SD(I,26)*ST(I,26)
C     CHECK FOR ZERO DATA AT HEIGHT 25
      IHV=26
      SPR=SP(I,26)
      SDR=SD(I,26)
      STR=ST(I,26)
      IF (CHECK.GT.0.) GO TO 491
      DO 420 J1=1,25,1
      J=26-J1
      CHECK = P(I,J) * D(I,J) * T(I,J) * SP(I,J) * SD(I,J) * ST(I,J)
C      FINDS INDEX IHV OF HIGHEST HEIGHT WITH NON-ZERO DATA
      IHV = J
      IF (CHECK.GT.0.) GO TO 440
  420 CONTINUE
C     HEIGHT = HEIGHT INDEX - 1
  440 Z1 = IHV -1.
C     SPR,SDR,STR=SIGMAS AT HEIGHT Z1
      SPR = SP(I,IHV)
      SDR=SD(I,IHV)
      STR=ST(I,IHV)
C.....IF HEIGHT Z1 GEQ 20 KM, USE GROVES AT 30 KM FOR INTERPOLATION,
C        OTHERWISE USE GROVES AT 25 KM
      IF (IHV.GE.21) GO TO 480
C.....EVALUATES GROVES AT 25 KM FOR INTERPOLATION AND
C        FILL IN OF ZERO DATA
      CALL GTERP(25,GLAT(I),P2,D2,T2,PG,DG,TG,DPY,DTY,DP2Y)
      IHP = IHV + 1
      DO 450 K=IHP,26
C.....AVOIDS INTERPOLATION OF P,D,T IF ONLY SIGMAS ARE ZERO
      IF ((P(I,K)*D(I,K)*T(I,K)).GT.0.) GO TO 445
      H=K-1
C.....INTERPOLATES BETWEEN 4D AT HEIGHT Z1 AND GROVES AT 25 TO FILL
C        IN MISSING DATA
      CALL INTER2(P(I,IHV),D(I,IHV),T(I,IHV),Z1,P2,D2,T2,25.,PH,DH,TH,H)
      P(I,K)=PH
      D(I,K)=DH
      T(I,K)=TH
  445 SP(I,K) = SPR
```

```
      SD(I,K)=SDR                                                       GEN4 142
C.....SETS MISSING SIGMAS EQUAL TO SIGMAS AT HEIGHT Z1                  GEN4 143
  450 ST(I,K)=STR                                                       GEN4 144
      GO TO 500                                                         GEN4 145
C.....EVALUATES GROVES AT 30 KM FOR INTERPOLATION AND FILL IN OF        GEN4 146
C        ZERO DATA                                                      GEN4 147
  480 CALL GTERP(30,GLAT(I),P2,D2,T2,PG,DG,TG,DPY,DTY,DP2Y)             GEN4 148
      CALL PDTUV(PSP,DSP,TSP,GLAT(I),GLON(I),30,DP,DD,DT,DPX,DPY,DTX,DTYGEN4 149
C     COMPUTE PERTURBATIONS TO GROVES MODEL                             GEN4 150
     $ ,DP2X,DP2Y,DPXY)                                                 GEN4 151
C.....ADD STATIONARY PERTURBATIONS TO GROVES MODEL                      GEN4 152
      P2 = P2*(1. + DP)                                                 GEN4 153
      D2 = D2*(1. + DD)                                                 GEN4 154
      T2 = T2*(1. + DT)                                                 GEN4 155
      IHP = IHV + 1                                                     GEN4 156
      DO 490 K=IHP,26                                                   GEN4 157
C.....AVOIDS INTERPOLATING P,D,T IF ONLY SIGMAS ARE ZERO                GEN4 158
      IF ((P(I,K)*D(I,K)*T(I,K)).GT.0.) GO TO 485                       GEN4 159
      H=K-1                                                             GEN4 160
C.....INTERPOLATES BETWEEN 4D AT HEIGHT Z1 AND GROVES AT 30 KM TO       GEN4 161
C        FILL IN MISSING DATA                                           GEN4 162
      CALL INTER2(P(I,IHV),D(I,IHV),T(I,IHV),Z1,P2,D2,T2,30.,PH,DH,TH,H)GEN4 163
      P(I,K)=PH                                                         GEN4 164
      D(I,K)=DH                                                         GEN4 165
      T(I,K)=TH                                                         GEN4 166
  485 SP(I,K) = SPR                                                     GEN4 167
      SD(I,K)=SDR                                                       GEN4 168
C     SET MISSING SIGMAS AT HEIGHT 1                                    GEN4 169
  490 ST(I,K) = STR                                                     GEN4 170
  491 CONTINUE                                                          GEN4 171
      IHP = IHV - 1                                                     GEN4 172
      DO 492 K=2,9                                                      GEN4 173
      IF (SP(I,K) .LE . 0.) SP(I,K) = SP(I,1)                           GEN4 174
      IF (SD(I,K) .LE. 0.) SD(I,K)= SD(I,1)                             GEN4 175
  492 IF (ST(I,K) .LE. 0.) ST(I,K) = ST(I,1)                            GEN4 176
      DO 495 K=10,IHP                                                   GEN4 177
C......SETS ALL ZERO SIGMAS TO SIGMA AT HEIGHT Z1                       GEN4 178
      IF (SP(I,K).LE.0.0.AND.P(I,K).GT.0.) SP(I,K) = SPR                GEN4 179
      IF (SD(I,K).LE.0.0.AND.D(I,K).GT.0.) SD(I,K) = SDR                GEN4 180
  495 IF (ST(I,K).LE.0.0.AND.T(I,K).GT.0.) ST(I,K) = STR                GEN4 181
  500 PA = P(I,1)                                                       GEN4 182
      TA = T(I,1)                                                       GEN4 183
      R =287.05                                                         GEN4 184
      G=GZ*(1.+(Z/(RI-Z))**2)                                           GEN4 185
      K = 2                                                             GEN4 186
  510 PB = P(I,K)                                                       GEN4 187
      TB = T(I,K)                                                       GEN4 188
      IF ((PB*TB) .GT. 0.) GO TO 520                                    GEN4 189
      K = K + 1                                                         GEN4 190
      GO TO 510                                                         GEN4 191
  520 IF (TA-TB) 560, 570, 560                                          GEN4 192
  560 TZ = (TA-TB) / ALOG(TA/TB)                                        GEN4 193
      GO TO 57                                                          GEN4 194
  570 TZ = TA                                                           GEN4 195
```

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```
  575 HS = K-1.+0.001*R*TZ*ALOG(PB/PA)/G
      KN=K-2
      IF(ABS(K-1-HS).GT.0.1) GO TO 578
      GAM=TB-T(I,K+1)
      IF(GAM) 582,590,582
  578 IF(TA-TB) 580,590,580
  580 GAM=(TA-TB)/(K-1-HS)
  582 KN1=KN+1
      IF(ABS(GAM).GT.G) GAM=SIGN(G,GAM)
      DO 585 JD=1,KN1,1
      J=JD-1
      TJ=TA-GAM*(J-HS)
      PJ=PA*(TJ/TA)**(G/(R*GAM*0.001))
      DJ=PJ/(R*TJ)
      P(I,J+1)=PJ
      D(I,J+1)=DJ
  585 T(I,J+1)=TJ
      GO TO 599
  590 KN1=KN+1
      DO 595 JD=1,KN1,1
      J=JG-1
      TJ=TA
      PJ=PA*EXP(-G*(J-HS)/(R*0.001*TJ))
      DJ=PJ/(R*TJ)
      P(I,J+1)=PJ
      D(I,J+1)=DJ
  595 T(I,J+1)=TJ
      IF(NSAME.EQ.2) NSAME=1
  599 HS=0.
      KOUNT = I
      CALL ADJUST
  600 CONTINUE
      RETURN
      END
      SUBROUTINE GETNMC
C
C     READS 'SETUP' DATA TAPE, OR NMC GRID DATA CARDS,
C     AND WRITES SCRATCH FILE FOR USE BY SELEC4.
C
      DIMENSION IP(15)
C
      COMMON /IOTEMP/ IOTEM1,IOTEM2,IUG,NMCOP,IDUM(60)
C
      NREC=0
      IF(NMCOP.NE.0) GO TO 2
C
1     READ(IUG,300,END=90) N,IP
300   FORMAT(A2,19I7)
      IF(N.NE.'W') GO TO 6
      GO TO 3
    2 READ(5,100) (IP(I),I=1,15)
  100 FORMAT(15I5)
    3 DO 4 I=1,15,3
      N=IP(I)
```

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```
      IF(M.LT.1) GO TO 5                                                GETN  21
      IJ=IP(I+1)*1000+IP(I+2)                                           GETN  22
      WRITE(IOTEM2) IJ                                                  GETN  23
      NREC=NREC+1                                                       GETN  24
    4 CONTINUE                                                          GETN  25
      IF(NMCOP.NE.0) GO TO 2                                            GETN  26
      GO TO 1                                                           GETN  27
    5 IF(NREC.NE.1977) GO TO 6                                          GETN  28
C     MOVES PAST FIRST EOF ON UNIT IUG                                  GETN  29
41    READ(IUG,9999,END=42) IDUMMY                                      GETN  30
9999  FORMAT(A10)                                                       GETN  31
      GO TO 41                                                          GETN  32
42    RETURN                                                            GETN  33
    6 WRITE(6,200) NREC,IOTEM2                                          GETN  34
  200 FORMAT(1H1/1X,I6,' RECORDS WRITTEN BY GETNMC IN SCRATCH FILE',I3) GETN  35
      STOP                                                              GETN  36
90    WRITE(6,400) IUG                                                  GETN  37
400   FORMAT('1  PREMATURE END-OF-FILE FOUND ON UNIT ',I2/              GETN  38
     Z'0  CALLED FROM SUBROUTINE GETNMC.')                              GETN  39
      STOP                                                              GETN  40
      END                                                               GETN  41
      SUBROUTINE GRID4D                                                 GRID   1
      INTEGER FLD                                                       GRID   2
      REAL LAT,LON                                                      GRID   3
      COMMON/C4/LAT(16),LON(16),NP,P(16,26),R(16,26),T(16,26),SP(16,26),GRID   4
     $ SR(16,26),ST(16,26)                                              GRID   5
      COMMON /PDTCOM/ IT,MONTH                                          GRID   6
C                                                                       GRID   7
C     S                                                                 GRID   8
C     SUBROUTINE TO SELECT PRESSURE, TEMPERATURE, AND DENSITY PROFILES (GRID   9
C     TOGETHER WITH THE NORMALIZED VARIANCES IN EACH, AT UP TO 16 'GRID GRID  10
C     AT LAT/LONS SELECTED BY CALLING PROGRAM.                          GRID  11
C                                                                       GRID  12
C     USES NASA HUNTSVILLE MSFC 4-D DATA TAPES                          GRID  13
C                                                                       GRID  14
      DIMENSION IN(107),BUFFER(64)                                      GRID  15
C                                                                       GRID  16
      COMMON /IOTEMP/ IOTEM1,IOTEM2                                     GRID  17
      COMMON /POINT/ IPT(16,5),LL(16),DXY(16,2)                         GRID  18
      COMMON /ORDER/ IPTN(16,5),IREAD(65,3)                             GRID  19
      COMMON /INT/ D(208,5),IG(5),DYX(2),DLA(4),DLO(4)                  GRID  20
C                                                                       GRID  21
      INTEGER IOTEM1,READ,WRITE                                         GRID  22
C                                                                       GRID  23
C                                                                       GRID  24
C     INITIALIZE                                                        GRID  25
C                                                                       GRID  26
      ZERO=0.0                                                          GRID  27
      ONE=1.0                                                           GRID  28
      TEN=10.0                                                          GRID  29
      HUNDR=100.0                                                       GRID  30
      THOU=1000.0                                                       GRID  31
      READ=6H READ                                                      GRID  32
      WRITE=6H WRITE                                                    GRID  33
```

```
C
      N=MONTH-1-((2*MONTH)/9)*4
      IF(MONTH.EQ.13) N=0
      NUNEOF = 0
      CALL NTRAN(IT,10,22)
      IF (N.EQ.0) GO TO 20
      CALL NTRAN(IT,8,N,22)
C
C     APPROPRIATE 4-D INPUT TAPE NOW POSITIONED - FILE NEEDED PROFILES
C
C
   20 CALL SELEC4
C
      IRC=0
      IRN=1
      IF(IREAD(IRN,3).EQ.0) GO TO 39
   21 JT=IT
      N=READ
   22 CALL NTRAN(IT,2,106,IN,L,22)
      IRC =IRC +1
      IF (L.EQ.-2) GO TO 39
      IF (L.LT.0) WRITE(6,23) IT,L,IRC
   23 FORMAT(' INPUT UNIT NO.',I3,' IN FRROR (',I2,') FOR RECORD NO.',I5
     1)
      IF(IRC.LT.IREAD(IRN,3)) GO TO 22
      IF(IRC.GT.IREAD(IRN,3)) GO TO 39
   24 I=IREAD(IRN,1)
      J=IREAD(IRN,2)
      IF(IRN.EQ.1) GO TO 25
      IF(IREAD(IRN,3).EQ.IREAD(IRN-1,3)) GO TO 27
   25 IP=FLD(12,12,IN(106))
      NP=FLD(24,12,IN(106))
      IF((NP.NE.MONTH).OR.(IP.NE.IPT(I,J))) GO TO 39
      DO 26 IK=1,106,1
      K=107-IK
      IN(K+1)=IN(K)
   26 CONTINUE
   27 FLD(0,18,IN(1)) = I
      FLD(18,18,IN(1)) = J
      JT=IOTEM1
      N=WRITE
      WRITE(IOTEM1) IN
      IRN=IRN+1
      IF(IREAD(IRN,3).EQ.IRC) GO TO 24
      IF(IREAD(IRN,3).EQ.0) GO TO 28
      GO TO 21
C
C     INTERPOLATE TO GIVEN LAT/LON FROM GRID DATA
C
   28 N=READ
      DO 38 II=1,NP
      DO 29 I=1,208
      DO 29 J=1,5
      D(I,J)=0.0
   29 CONTINUE
      DO 32 J=1,4
      IF(IPT(II,J).EQ.0) GO TO 32
      FLD(0,18,INDEX) = II
      FLD(18,18,INDEX) = J
      REWIND IOTEN1
30    READ(IOTEN1,END=39) IN
      IF(IN(1).NE.INDEX) GO TO 30
      DO 31 I=2,105
      J2=2*I-2
      J1=J2-1
      D(J1,J)=FLD(0,18,IN(I))/HUNDR
      D(J2,J)=FLD(18,18,IN(I))/HUNDR
   31 CONTINUE
      DLA(J)=FLD(0,18,IN(106))/TEN
      DLO(J)=FLD(18,18,IN(106))/TEN
   32 CONTINUE
C
C     IF NECESSARY, INTERPOLATE
C
      LALO=LL(II)
      DO 33 I=1,5
      IG(I)=IPT(II,I)
   33 CONTINUE
      IF(IG(2).NE.0) GO TO 35
      DO 34 I=1,208
      D(I,5)=D(I,1)
   34 CONTINUE
      GO TO 37
   35 IF(IG(5).NE.2) GO TO 36
      DYX(1)=DXY(II,1)
      DYX(2)=DXY(II,2)
C
   36 CALL INTRP4 (LALO)
C
   37 DO 38 I=1,26
      P(II,I)=D(I,5)*HUNDR
      R(II,I)=D(I+156,5)/THOU
      T(II,I) =D(I+52,5)
      DIVIDE=ONE
      IF(P(II,I).GT.ZERO) DIVIDE=(P(II,I)/HUNDR)**2
      SP(II,I)=D(I+26,5)/DIVIDE
      DIVIDE=ONE
      IF(R(II,I).GT.ZERO) DIVIDE=(THOU*R(II,I))**2
      SR(II,I)=D(I+182,5)/DIVIDE
      DIVIDE=ONE
      IF(T(II,I).GT.ZERO) DIVIDE=T(II,I)**2
      ST(II,I)=D(I+78,5)/DIVIDE
   38 CONTINUE
      RETURN
   39 WRITE(6,40) JT,IRC,IREAD(IRN,3),NP,MONTH,IP,I,J,IPT(I,J),IRN,N,L
   40 FORMAT(' ***** UNIT NO.',I3,' IN ERROR',I7,' RECORDS READ'/
     1' IREAD(IRN,3) =',I5,' NP =',I3,' MONTH =',I3,
     2' IP =',I5,' IPT(',I2,',',I1,') =',I5,' IRN =',I3/A6,' STATUS',I5)
```

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      STOP
      END
      SUBROUTINE GROUP
      DIMENSION KOU(2)
      COMMON/CHIC/LA(4,4),NB(2),IWSYN,UCOEF(14,9),VCOEF(14,9)
      COMMON /CHK/P(4,4,3),DEN(4,4,3),NO(2)
      COMMON /WINCON/DGH,FCORY,DX5,DY5
      FCORX = FCORY*DX5/DY5
      KK=1
      DO 100 I=1,4
      DO 100 J=1,4
      LA(I,J)=4*(I-1)+J
  100 CONTINUE
  200 CONTINUE
      DO 250 M=1,4
      DO 250 N=1,4
      IF (KK.EQ.1) GO TO 210
      I=5-M
      J=5-N
      NN=-1
      N4=-1
      GO TO 220
  210 CONTINUE
      I=M
      J=N
      NN=1
      N4=1
  220 CONTINUE
      IF (N.EQ.4) GO TO 225
      DINX=FCORX* (DEN(I,J+NN,2)+DEN(I,J,2))/2
      VY=(P(I,J+NN,2)-P(I,J,2))/DINX
      IF(ABS(VY).GT.100) GO TO 225
      LA(I,J)=MIN0(LA(I,J),LA(I,J+NN))
      LA(I,J+NN)=LA(I,J)
  225 CONTINUE
      IF(M.EQ.4) GO TO 250
      DINY=FCORY* (DEN(I+N4,J,2)+DEN(I,J,2))/2
      VX=(P(I+N4,J,2)-P(I,J,2))/DINY
      IF(ABS(VX).GT.100) GO TO 250
      LA(I,J)=MIN0(LA(I,J),LA(I+N4,J))
      LA(I+N4,J)=LA(I,J)
  250 CONTINUE
      KK=KK+1
      IF(KK.EQ.2) GO TO 200
      NO(1)=0
      NO(2)=0
      II=1
      DO 400 LL=1,11
      KOU(II)=1
      DO 300 I=1,4
      DO 300 J=1,4
      IF(LA(I,J).EQ.LL) KOU(II)=KOU(II)+1
  300 CONTINUE
      IF (KOU(II).GE.7) NO(II)=LL
      IF (KOU(II).GE.7) II=2                                            GROU  53
  400 CONTINUE                                                          GROU  54
      RETURN                                                            GROU  55
      END                                                               GROU  56
      SUBROUTINE GTERP(IH,PHI,P,D,T,PG,DG,TG,DPY,DTY,DP2Y)              GTER   1
C.....INTERPOLATES GROVES DATA TO HEIGHT IH AND LATITUDE PHI             GTER   2
      DIMENSION PG(18,19),TG(18,19),DG(18,19)                           GTER   3
C     HEIGHT INDEX                                                      GTER   4
      I =(IH - 20)/5                                                    GTER   5
C     LOWER LATITUDE INDEX                                              GTER   6
      J = INT((PHI + 100.)/10.)                                         GTER   7
      IF (J.LT.1) J = 1                                                 GTER   8
      IF (J.GT.18) J = 18                                               GTER   9
C     UPPER LATITUDE INDEX                                              GTER  10
      JP = J + 1                                                        GTER  11
C.....CHECK FOR DENSITY OR TEMPERATURE LEQ 0                             GTER  12
      CHK = DG(I,J) * TG(I,J) * DG(I,JP) * TG(I,JP)                     GTER  13
      IF (CHK) 10,10,20                                                 GTER  14
 10   P = PG(I,J)                                                       GTER  15
      D = DG(I,J)                                                       GTER  16
      T = TG(I,J)                                                       GTER  17
      GO TO 30                                                          GTER  18
C.....LATITUDE DEVIATION FROM GROVES ARRAY POSITION                      GTER  19
 20   PHIF = (PHI + 100. - 10.*J)/10.                                   GTER  20
      TL= TG(I,J) + (TG(I,JP ) - TG(I,J))*PHIF                          GTER  21
C      LATITUDE INTERPOLATION                                           GTER  22
      DL= DG(I,J) + (DG(I,JP ) - DG(I,J)) *PHIF                         GTER  23
      R1 = PG(I,J)/(DG(I,J)*TG(I,J))                                    GTER  24
      R2 = PG(I,JP)/(DG(I,JP)*TG(I,JP))                                 GTER  25
C     INTERPOLATED GAS CONSTANT                                         GTER  26
      R = R1 + (R2 - R1)*PHIF                                           GTER  27
C     PRESSURE COMPUTED FROM INTERPOLATED GAS CONSTANT                  GTER  28
      P =DL*R*TL                                                        GTER  29
      D = DL                                                            GTER  30
      T = TL                                                            GTER  31
C     DP/DY FOR GEOSTOPHIC WINDS                                        GTER  32
 30   DPY = (PG(I,JP) - PG(I,J)) * 0.5                                  GTER  33
C     DT/DY FOR THERMAL WINDS                                           GTER  34
      DTY = (TG(I,JP) - TG(I,J)) * 0.5                                  GTER  35
      JM = J - 1                                                        GTER  36
      IF (JM.LT.1) JM = JP                                              GTER  37
      DP2Y = (PG(I,JP) - PG(I,JM ))*0.5                                 GTER  38
      IF (ABS(PHI)-90.) 50,40,40                                        GTER  39
40    DPY = 0.                                                          GTER  40
      DTY = 0.                                                          GTER  41
      DP2Y = 0.                                                         GTER  42
50    CONTINUE                                                          GTER  43
      RETURN                                                            GTER  44
      END                                                               GTER  45
      SUBROUTINE INTERW(U1,V1,Z1,U2,V2,Z2,U,V,Z)                        INTE   1
      IF ( Z1 - Z2 ) 20,10,20                                           INTE   2
   10 U = U1                                                            INTE   3
C     SETS U,V = U1,V1 IF Z1 = Z2                                       INTE   4
      V = V1                                                            INTE   5
      RETURN                                                            INTE   6
   20 A = (Z-Z1)/(Z2-Z1)                                                INTE   7
      U = U1 + (U2-U1) * A                                              INTE   8
      V = V1 + (V2-V1) * A                                              INTE   9
C.....LINEAR INTERPOLATION BETWEEN U1,V1 AT HEIGHT Z1 AND U2,V2 AT      INTE  10
C        HEIGHT Z2.  OUTPUT IS U,V AT HEIGHT Z                          INTE  11
      RETURN                                                            INTE  12
      END                                                               INTE  13
      SUBROUTINE INTERZ(P1,D1,T1,Z1,P2,D2,T2,Z2,P,D,T,Z)                INTE   1
    5 IF (Z1 - Z2)  20,10,20                                            INTE   2
 10   P = P1                                                            INTE   3
      D = D1                                                            INTE   4
C     SETS P, D, T = P1,D1,T1, IF Z1 = Z2                               INTE   5
      T =T1                                                             INTE   6
      RETURN                                                            INTE   7
 20   A = (Z - Z1)/ (Z2 - Z1)                                           INTE   8
      T = T1 + (T2 - T1)*A                                              INTE   9
      D = D1 + (D2 - D1)*A                                              INTE  10
      P = P1 + (P2 - P1) * A                                            INTE  11
C.....LINEAR INTERPOLATION BETWEEN P1,D1,T1 AT HEIGHT Z1 AND P2,D2,T2   INTE  12
C        AT HEIGHT Z2 TO OUTPUT VALUES OF P,D,T AT HEIGHT Z             INTE  13
      RETURN                                                            INTE  14
      END                                                               INTE  15
      SUBROUTINE INTER2(P1,D1,T1,Z1,P2,D2,T2,Z2,P,D,T,Z)                INTE   1
C.....INTERPOLATES BETWEEN P1,D1,T1 AT HEIGHT Z1 AND P2,D2,T2 AT        INTE   2
C        HEIGHT Z2 TO OUTPUT VALUES OF P,D,T AT HEIGHT Z                INTE   3
C.....CHECKS FOR T1,D1,T2,D2 PRODUCT = 0, FOR GAS CONSTANT INTERPOLATIONINTE   4
      CHK=T1*D1*T2*D2                                                   INTE   5
      IF (CHK) 10,10,5                                                  INTE   6
    5 IF (Z1 - Z2)  20,10,20                                            INTE   7
 10   P = P1                                                            INTE   8
      D = D1                                                            INTE   9
C       SETS P,D,T = P1,D1,T1 IF Z1=Z2                                  INTE  10
      T = T1                                                            INTE  11
      RETURN                                                            INTE  12
   20 IF(P1*D1*T1*P2*D2*T2.LE.0.)GO TO 30                               INTE  13
      A=ALOG(D2/D1)/(Z2-Z1)                                             INTE  14
C      LINEAR INTERPOLATION ON LOG D                                    INTE  15
      DZ= D1*EXP(A*(Z - Z1))                                            INTE  16
      A=(Z-Z1)/(Z2-Z1)                                                  INTE  17
C      LINEAR INTERPOLATION ON T                                        INTE  18
      TZ= T1 + A*(T2-T1)                                                INTE  19
      R1=P1/(D1*T1)                                                     INTE  20
      R2=P2/(D2*T2)                                                     INTE  21
C      LINEAR INTERPOLATION ON GAS CONSTANT R                           INTE  22
      R=(R2-R1)*A+R1                                                    INTE  23
C       PRESSURE FROM PERFECT GAS LAW                                   INTE  24
      P = DZ * R * TZ                                                   INTE  25
      D = DZ                                                            INTE  26
      T = TZ                                                            INTE  27
      RETURN                                                            INTE  28
   30 P=0.                                                              INTE  29
      D=0.                                                              INTE  30
      T=0.                                                              INTE  31
      RETURN                                                            INTE  32
      END                                                               INTE  33
      SUBROUTINE INTER4 (              CLAT, CLON, IZ,     P, D, T,     INTE   1
     * P4, D4, T4, DPX, DPY, DTX, DTY,DPXX,DPYY,DPXY)                   INTE   2
      COMMON/IOTEMP/IOTEM1,IOTEM2,IU6,MMCOP,EQ,XMJD,PHI1,PHI,           INTE   3
     .NSAME                                                             INTE   4
C.....INTERPOLATES BETWEEN 4D ARRAYS P(I,IH),D(I,IH),T(I,IH) AT GRID    INTE   5
C        LOCATIONS LATITUDE GLAT(I) LONGITUDE GLON(I).                  INTE   6
C        CLAT,CLON = CURRENT LATITUDE,LONGITUDE                         INTE   7
C        IZ = HEIGHT                      NG = NUMBER OF 4D GRID POSITIONS INTE   8
C        OUTPUT = P4,D4,T4, AND DERIVATIVES DPX,DPY,DTX,DTY             INTE   9
      COMMON /C4/ GLAT(16),GLON(16),NG                                  INTE  10
      COMMON/CHIC/LA(4,4),NB(2),IWSYM,UCOEF(14,9),VCOEF(14,9)           INTE  11
      DIMENSION                   P(16,26),D(16,26),T(16,26),LAX(16)    INTE  12
      IWSYM = ' '                                                       INTE  13
      ICHK = 0                                                          INTE  14
C     HEIGHT INDEX = HEIGHT + 1                                         INTE  15
      IH = IZ + 1                                                       INTE  16
    5 IF (ICHK.GT.1) GO TO 220                                          INTE  17
      IF (NG.GT.9) GO TO 100                                            INTE  18
C     NG = 9 MEANS POLAR GRID                                           INTE  19
      DO 10 I=10,16,1                                                   INTE  20
      P(I,IH) = P(9,IH)                                                 INTE  21
      D(I,IH) = D(9,IH)                                                 INTE  22
      T(I,IH) = T(9,IH)                                                 INTE  23
      GLAT(I) = GLAT(9)                                                 INTE  24
C     I=10-16 ALL AT 90 DEG                                             INTE  25
   10 GLON(I) = GLON(I-8)                                               INTE  26
C     LOWER RIGHT INTERPOLATION INDEX                                   INTE  27
      IB = INT(CLON/45) + 1                                             INTE  28
C     LOWER LEFT INTERPOLATION INDEX                                    INTE  29
      IA =IB+1                                                          INTE  30
      IF (IA.GT.8) IA = IA-8                                            INTE  31
C     POSITION OUTSIDE POLAR GRID                                       INTE  32
      IF (ABS(CLAT).LT.75.) GO TO 20                                    INTE  33
C     UPPER LEFT INTERPOLATION INDEX                                    INTE  34
      IC = IA +8                                                        INTE  35
C     UPPER RIGHT INTERPOLATION INDEX                                   INTE  36
      ID = IB + 8                                                       INTE  37
      GO TO 300                                                         INTE  38
 20   IF(NSAME.EQ.1) NSAME=2                                            INTE  39
      CALL GEN4D                                                        INTE  40
      IWSYM = '*'                                                       INTE  41
      ICHK = ICHK + 1                                                   INTE  42
      GO TO 5                                                           INTE  43
  100 XLON = CLON                                                       INTE  44
      DO 105 I = 1,4                                                    INTE  45
      DO 105 J = 1,4                                                    INTE  46
      I16 = 4*(I-1) + J                                                 INTE  47
      LAX(I16) = LA(I,J)                                                INTE  48
 105   CONTINUE                                                         INTE  49
      IF (CLON.GT.345) XLON = CLON - 360.                               INTE  50
C.....CHECKS FOR POSITION WITHIN 16 POINT GRID 110=GOOD.  200=POSITION  INTE  51
C        OUTSIDE GRID.                                                  INTE  52
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      IF (CLAT.GE.GLAT(1) .AND. CLAT.LT.GLAT(16) .AND. XLON.LE.GLON(1)  INTE  53
     $  .AND.XLON.GT.GLON(16)) GO TO 110                                INTE  54
      GO TO 200                                                         INTE  55
 110  NDL=5                                                             INTE  56
      IF(ABS(CLAT).LT.18) NDL=12                                        INTE  57
      IA = 1 + INT((GLON(1) - XLON) / 5)                                INTE  58
C.....IA = LOWER LEFT (REFERENCE) INTERPOLATION INDEX                    INTE  59
      IA = IA + 4 * INT((CLAT - GLAT(1)) / NDL)                         INTE  60
C     LOWER RIGHT INTERPOLATION INDEX                                   INTE  61
      IB = IA + 1                                                       INTE  62
C     UPPER LEFT INTERPOLATION INDEX                                    INTE  63
      IC = IA + 4                                                       INTE  64
C     UPPER RIGHT INTERPOLATION INDEX                                   INTE  65
      ID = IA + 5                                                       INTE  66
      IF(LAX(IA).EQ.NB(1).OR.LAX(IA).EQ.NB(2).OR.LAX(IB).NE.LAX(IA).    INTE  67
     *  OR.LAX(IC).NE.LAX(IA).OR.LAX(ID).NE.LAX(IA))IWSYM='*'           INTE  68
      GO TO 300                                                         INTE  69
 200  IF(NSAME.EQ.1)NSAME=2                                             INTE  70
      CALL GEN4D                                                        INTE  71
      IWSYM = '*'                                                       INTE  72
      ICHK = ICHK + 1                                                   INTE  73
      GO TO 5                                                           INTE  74
  220 WRITE(6,250)                                                      INTE  75
 250  FORMAT('  UNABLE TO GENERATE 4-D GRID')                           INTE  76
      P4=0.                                                             INTE  77
      D4=0.                                                             INTE  78
      T4=0.                                                             INTE  79
      RETURN                                                            INTE  80
C.....INTERPOLZTION FOR POSITION INSIDE 16 POINT GRID OR POLAR GRID      INTE  81
  300 CALL INTLL(P,IA,IB,IC,ID,P4,GLAT,GLON,CLAT,CLON,IN)               INTE  82
      CALL INTLL(D,IA,IB,IC,ID,D4,GLAT,GLON,CLAT,CLON,IN)               INTE  83
      CALL INTLL(T,IA,IB,IC,ID,T4,GLAT,GLON,CLAT,CLON,IN)               INTE  84
C.....RELATIVE LONGITUDE DISPLACEMENT FROM REFERENCE POSITION (IA)       INTE  85
      DLON = (CLON - GLON(IA))/(GLON(IB) - GLON(IA))                    INTE  86
C.....RELATIVE LATITUDE DISPLACEMENT FROM REFERENCE POSITION(IA)         INTE  87
      DLAT = (CLAT - GLAT(IA))/(GLAT(IC) - GLAT(IA))                    INTE  88
      DPX=P(IB,IN)-P(IA,IN)                                             INTE  89
C.....DP/DX FOR GEOSTROPHIC WIND EQUATIONS                               INTE  90
      DPX = DPX + (P(ID,IN) - P(IC,IN) - DPX)*DLAT                      INTE  91
      DTX = T(IB,IN) - T(IA,IN)                                         INTE  92
C.....DT/DX FOR THERMAL WIND EQUATIONS                                   INTE  93
      DTX = DTX + (T(ID,IN) - T(IC,IN) - DTX)*DLAT                      INTE  94
      DPY = P(IC,IN) - P(IA,IN)                                         INTE  95
C.....DP/DY FOR GEOSTROPHIC WIND EQUATIONS                               INTE  96
      DPY = DPY + (P(ID,IN) - P(IB,IN) - DPY)*DLON                      INTE  97
      DTY = T(IC,IN) - T(IA,IN)                                         INTE  98
C.....DT/DY FOR THERMAL WIND EQUATIONS                                   INTE  99
      DTY = DTY + (T(ID,IN) - T(IB,IN) - DTY)*DLON                      INTE 100
      IF(NG.GT.9) GO TO 315                                             INTE 101
      DPX=DPX/9.                                                        INTE 102
      DTX=DTX/9.                                                        INTE 103
      DPY=DPY/3.                                                        INTE 104
      DTY=DTY/3.                                                        INTE 105
 315  IF(ABS(CLAT).GT.18) GO TO 312                                     INTE 106
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```
      DPY=DPY*5./12                                                    INTE 107
      DTY=DTY*5./12                                                    INTE 108
  312 IF (NG.GT.9) GO TO 310                                           INTE 109
      DPXX = 0.                                                        INTE 110
      DPYY = 0.                                                        INTE 111
      DPXY = 0.                                                        INTE 112
      RETURN                                                           INTE 113
  310 DPXY = P(ID,IH) - P(IC,IH) - P(IB,IH) + P(IA,IH)                 INTE 114
      IF (MOD(IB,4) .EQ.0) GO TO 320                                   INTE 115
      I1 = IA                                                          INTE 116
      I2 = IB + 1                                                      INTE 117
      I3 = IC                                                          INTE 118
      I4 = ID + 1                                                      INTE 119
      SX=1.                                                            INTE 120
      GO TO 330                                                        INTE 121
  320 I1 = IA - 1                                                      INTE 122
      I2 = IB                                                          INTE 123
      I3 = IC - 1                                                      INTE 124
      I4 = ID                                                          INTE 125
      SX=-1.                                                           INTE 126
  330 IF(LAX(I1).NE.LAX(IA).OR.LAX(I2).NE.LAX(IA).OR.LAX(I3).NE.       INTE 127
     * LAX(IA).OR.LAX(I4).NE.LAX(IA)) GO TO 360                        INTE 128
      DPXX = P(I2,IH) - P(I1,IH)                                       INTE 129
      DPXX = DPXX + (P(I4,IH) - P(I3,IH) - DPXX)*DLAT                  INTE 130
      IF (IC.GT.12) GO TO 340                                          INTE 131
      I1 = IA                                                          INTE 132
      I2 = IC + 4                                                      INTE 133
      I3 = IB                                                          INTE 134
      I4 = ID + 4                                                      INTE 135
      SY=1.                                                            INTE 136
      GO TO 350                                                        INTE 137
  340 I1 = IA - 4                                                      INTE 138
      I2 = IC                                                          INTE 139
      I3 = IB - 4                                                      INTE 140
      I4 = ID                                                          INTE 141
      SY=-1.                                                           INTE 142
  350 IF(LAX(I1).NE.LAX(IA).OR.LAX(I2).NE.LAX(IA).OR.LAX(I3).NE.       INTE 143
     * LAX(IA).OR.LAX(I4).NE.LAX(IA)) GO TO 360                        INTE 144
      DPYY = P(I2,IH) - P(I1,IH)                                       INTE 145
      DPYY = DPYY + (P(I4,IH) - P(I3,IH) - DPYY)*DLON                  INTE 146
      DPXX =(DPXX - 2.*DPX )*SX                                        INTE 147
      DPYY =(DPYY - 2.*DPY )*SY                                        INTE 148
      RETURN                                                           INTE 149
  360 DPXX = 0.                                                        INTE 150
      DPYY = 0.                                                        INTE 151
      DPXY = 0.                                                        INTE 152
      IWSYM = '*'                                                      INTE 153
      RETURN                                                           INTE 154
      END                                                              INTE 155
      SUBROUTINE INTLL(F,IA,IB,IC,ID,FLL,GLAT,GLON,CLAT,CLON,IH)       INTL   1
C.....INTERPOLATES FUNCTION (ARRAY) F FROM VALUES OF GLAT AND GLON AT   INTL   2
C         INDEX VALUES IA, IB, IC, ID TO OUTPUT VALUE FLL AT HEIGHT IH  INTL   3
C         AND POSITION CLAT, CLON                                      INTL   4
      DIMENSION F(16,26),GLAT(16),GLON(16)                             INTL   5
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C.....NORMALIZES LONGITUDE DISPLACEMENT
      IF(F(IA,IH)*F(IB,IH)*F(IC,IH)*F(ID,IH)) 20,10,20
   10 FLL=0.
      RETURN
   20 X=(CLON-GLON(IB))/(GLON(IA)-GLON(IB))
C.....NORMALIZES LATITUDE DISPLACEMENT
      Y=(CLAT-GLAT(IA))/(GLAT(IC)-GLAT(IA))
C.....TWO DIMENSIONAL INTERPOLATION
      FLL=F(IB,IH)+(F(ID,IH)-F(IB,IH))*Y+(F(IA,IH)-F(IB,IH))*X
     1  +(F(IC,IH)-F(IA,IH)-F(ID,IH)+F(IB,IH))*X*Y
      RETURN
      END
      SUBROUTINE INTRP4 (LALON)
C
C        SUBROUTINE TO INTERPOLATE VALUES
C
      DIMENSION XLL(4),YLL(4),XC(4),YC(4)
C
      COMMON/INT/D(208,5),IG(5),DXY(2),DLA(4),DLO(4)
C
      DEGRAD=3.14159/180.
      LALO=IABS(LALON)
      L1=LALO/10000
      L2=LALO-L1*10000
      XL=L1/10.
      YL=L2/10.
      IF (IG(5)-2) 30,20,10
   10 IF (IG(5)-3) 30,30,50
C
C        INTERPOLATE FROM NMC GRID
C
   20 CONTINUE
      DO 25 L=1,26
      DO 22 J=1,4
   22 IF (D(L,J).LT.0.01) GO TO 25
      DO 24 K=1,8
      I=(K-1)*26+L
      D(I,5)=(1.-DXY(2))*((1.-DXY(1))*D(I,1)+DXY(1)*D(I,2))
     1 +DXY(2)*(((1.-DXY(1))*D(I,3))+DXY(1)*D(I,4))
   24 CONTINUE
   25 CONTINUE
      RETURN
C
C     INTERPOLATE FROM EQUATION FOR SOUTHERN HEMISPHERE GRID
C
   30 CONTINUE
      DO 32 J=1,2
      XLL(J)=DLA(J)
      YLL(J)=DLO(J)
      IF ((YL.GE.355.).AND.(YLL(J).LT.0.01)) YLL(J)=360.
   32 CONTINUE
      X=(YLL(1)-YL)/5.
      Y=(XL-XLL(1))/5.
      IF (IG(5).EQ.3) Y=-Y
      DO 36 L=1,26
      DO 36 J=1,4
   36 IF (D(L,J).LT.0.01) GO TO 38
      DO 37 K=1,8
      I=(K-1)*26+L
      D(I,5)=D(I,1)+X*(D(I,2)-D(I,1))+Y*(D(I,3)-D(I,1))+X*Y*
     1 (D(I,4)-D(I,3)-D(I,2)+D(I,1))
   37 CONTINUE
   38 CONTINUE
      RETURN
C
C          INTERPOLATE FROM ACROSS GRIDS
C
   50 CONTINUE
      IF (IG(5).NE.1133) GO TO 55
      IG(5)=3
      GO TO 30
   55 CONTINUE
      IF (IG(5).NE.333) GO TO 60
      DLO(1)=(DLO(2)+DLO(3))/2.
      DO 52 I=1,208
   52 D(I,4)=D(I,3)
      DLA(4)=DLA(3)
      DLO(4)=DLO(3)
   60 CONTINUE
      DO 62 I=1,4
      XLL(I)=DLA(I)
      YLL(I)=DLO(I)
      IF ((YL.GT.350.).AND.(YLL(I).LT.0.01)) YLL(I)=360.
   62 CONTINUE
      ITH=0
      X=YLL(1)-YL
      Y=XL-XLL(1)
   63 CONTINUE
      DO 65 I=2,4
      XC(I)=YLL(1)-YLL(I)
   65 YC(I)=XLL(I)-XLL(1)
      TH2=3.14159/4
      TH3=3.14159/4
      IF (ABS(XC(2)).GT.0.01) TH2=ATAN(YC(2)/XC(2))
      IF (ABS(YC(3)).GT.0.01) TH3=ATAN(XC(3)/YC(3))
      IF (XC(2).LT.0.) TH2=3.14159+TH2
      IF (XC(3).LT.0.) TH3=3.14159+TH3
      DNN=COS(TH2+TH3)
      IF (ABS(DNN).GT.0.001) GO TO 66
      ITH=ITH+1
      IF (ITH.EQ.2) GO TO 66
      XLL(3)=XLL(4)
      YLL(3)=YLL(4)
      DO 61 I=1,208
   61 D(I,3)=D(I,4)
      GO TO 63
   66 CONTINUE
      ZA=SQRT(XC(2)**2+YC(2)**2)
      IF (ITH.LT.2) GO TO 69
      Z=SQRT(X**2+Y**2)
      E=0.
      Z4=0.
      GO TO 71
   69 CONTINUE
      EB=SQRT(XC(3)**2+YC(3)**2)
      Z4=(XC(4)*COS(TH3)-YC(4)*SIN(TH3))/DNN
      E4=(YC(4)*COS(TH2)-XC(4)*SIN(TH2))/DNN
      Z=(X*COS(TH3)-Y*SIN(TH3))/DNN
      E=(Y*COS(TH2)-X*SIN(TH2))/DNN
      B=0.
      C=0.
      DD=0.
C
   71 CONTINUE
      DO 70 L=1,26
      DO 68 J=1,4
   68 IF (D(L,J).LT.0.01) GO TO 70
      DO 67 K=1,6
      I=(K-1)*26+L
      A=D(I,1)
      IF (ZA.GT.0.01) B=(D(I,2)-D(I,1))/ZA
      IF (EB.GT.0.01) C=(D(I,3)-D(I,1))/EB
      IF ((ABS(Z4).GT.0.01).AND.(ABS(E4).GT.0.01))
     1 DD=(D(I,4)-A-B*Z4-C*E4)/(Z4*E4)
      D(I,5)=A+B*Z+C*E+DD*Z*E
   67 CONTINUE
   70 CONTINUE
      RETURN
      END
      SUBROUTINE INTRUV(UR,VR,H,PHI,SUN,SVN)
C.....FINDS RANDOM WIND STANDARD DEVIATION AT HEIGHT H (KM), LATITUDE
C        PHI (DEGREES), FROM UR AND VR ARRAYS
      DIMENSION UR(25,10),VR(25,10)
C.....I - LOWER HEIGHT INDEX
      IF (H.LT.95.) I = 1 + INT(H) / 5
      IF (H.GE.95.) I=19+(INT(H)-80)/20
      IF (I.GT.25) I = 25
C     UPPER HEIGHT INDEX
      IP=I+1
      IF (IP.GT.25) IP=25
C     LOWER LATITUDE INDEX
      J=INT(PHI+110.)/20
C      UPPER LATITUDE INDEX
      JP=J+1
      IF (JP.GT.10) JP=10
C.....PHI1 - LOWER LATITUDE FOR UR AND VR ARRAY VALUES
      PHI1=-110.+20.*J
C.....PHI2 - UPPER LATITUDE FOR UR AND VR ARRAY VALUES
      PHI2=-110.+20.*JP
      IF (I.GT.19) GO TO 10
C      LOWER HEIGHT FOR UR AND VR ARRAY VALUES
      Z1=5.*(I-1)
      GO TO 20
10    Z1=20.*(I-15)
20    IF (IP.GT.19) GO TO 30
C       UPPER HEIGHT FOR UR AND VR ARRAY VALUES
      Z2=5.*(IP-1)
      GO TO 40
   30 Z2 = 20. * (IP - 15)
C      INTERPOLATE ON LATITUDE AT LOWER HEIGHT
   40 CALL INTERW(UR(I,J),VR(I,J),PHI1,UR(I,JP),VR(I,JP),PHI2,U1,V1,
     $PHI)
C       INTERPOLATE ON LATITUDE AT UPPER HEIGHT
      CALL INTERW(UR(IP,J),VR(IP,J),PHI1,UR(1P,JP),VR(IP,JP),PHI2,U2,V2,
     $PHI)
C       INTERPOLATE ON HEIGHT
      CALL INTERW(U1,V1,Z1,U2,V2,Z2,SUH,SVH,H)
      RETURN
      END
      SUBROUTINE JAC(Z,TZ,DENS)
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI,
     .          NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,
     $ MN, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,AP,
     .   IHR,MIN,NMORE,DX,HL,VL,DZ
      COMMON/COMJAC/XLAT,XLONG,SDA,SHA,DY,Y,T,EM
      DIMENSION ALPHA(6),EI(6),DI(6),     B(7),DIT(6)
      QQ = 100.
      DATA ALPHA/0.0,0.0,0.0,0.0,-0.38,0.0/
      DATA EI/28.0134,31.9988,15.9994,39.948,4.0026,1.00797/
      DATA B/28.15204,-0.085586,1.284E-04,-1.0056E-05,-1.021E-05,
     11.5044E-06,9.9826E-08/
      AV=6.02257E23
      QN=.78110
      QO2=.20955
      QA=.009343
      QHE = 1.289E-5
      FK=8.31432
C
C     TEMPERATURE AT Z = 125 KM, EQ. 9
C
      TX=444.3807+.02385*T -392.8292*EXP(-.0021357*T)
      A2=2.*(T-TX)/3.14159265
C
C
      DIT(6)=0.
      M=10
      EPS=.0001
C
C     TEMPERATURE FOR 90%Z%125, EQ. 10
C
      T1=1.9*(TX-183.)/35.
      T4=3.*(TX-183.-2.*T1*35./3.)/(35.**4)
      T3=-T1/(3.*35.**2)+4.*T4*35./3.
      TZ=TX+T1*(Z-125.)+T3*(Z-125.)**3+T4*(Z-125.)**4
      IF (Z-105.) 43,43,40
C
```

```
C     MEAN MOLECULAR WEIGHT FOR 90ZZZ105, EQ. 1
C
   43 Z2 = Z - QQ
      EM=B(1)+B(2)*Z2+B(3)*Z2**2+B(4)*Z2**3+B(5)*Z2**4+B(6)*Z2**5
     1+B(7)*Z2**6
      D=Z
70    CONTINUE
C
C     INTEGRATION OF EQ. 5 FOR DENSITY BETWEEN 90ZZZ105
C
      A=90.
      FA=B(1)+B(2)*(A-QQ)+B(3)*(A-QQ)**2+B(4)*(A-QQ)**3+B(5)*(A-QQ)**4
     1+B(6)*(A-QQ)**5 +B(7)*(A-QQ)**6
      FA=FA*9.80655/((1.+A/6.356766E+3)**2)
      FA=FA/(TX+T1*(A-125.)+T3*(A-125.)**3 +T4*(A-125.)**4)
      FD=B(1)+B(2)*(D-QQ)+B(3)*(D-QQ)**2+B(4)*(D-QQ)**3+B(5)*(D-QQ)**4
     1+B(6)*(D-QQ)**5 +B(7)*(D-QQ)**6
      FD=FD*9.80665/((1.+D/6.356766E+3)**2)
      FD=FD/(TX+T1*(D-125.)+T3*(D-125.)**3 +T4*(D-125.)**4)
C     SR04, SIMPSONS RULE QUADRATURE  -  G.F.KUNCIR
C     DEFINITIONS  -
C       A = LOWER LIMIT OF INTEGRATION
C       D = UPPER LIMIT OF INTEGRATION
C       FUNC = INTEGRAND FUNCTION SUBPROGRAM
C       EPS = RELATIVE ERROR CONVERGENCE CRITERION
C       M = MAXIMUM NUMBER OF INTEGRATIONS
C       R = RESULT OF INTEGRATION
C       N = NUMBER OF INTEGRATIONS9RIQ%IRID TO FIND R
C
      NINT = 1
      N=0
      PREV=0.
      SONE=(D-A)*(FA+FD)/2.
71    N=N+1
      IF (N-M) 72,72,75
72    NINT = 2 * NINT
      STWO=0.
      DEL=(D-A)/FLOAT(NINT)
      DO 73 I=1,NINT,2
      X=A+DEL*FLOAT(I)
      FX=B(1)+B(2)*(X-QQ)+B(3)*(X-QQ)**2+B(4)*(X-QQ)**3+B(5)*(X-QQ)**4
     1+B(6)*(X-QQ)**5 +B(7)*(X-QQ)**6
      FX=FX*9.80665/((1.+X/6.356766E+3)**2)
      FX=FX/(TX+T1*(X-125.)+T3*(X-125.)**3 +T4*(X-125.)**4)
73    STWO=STWO+FX
      CUR=SONE+4.*DEL*STWO
      IF (EPS*ABS(CUR)-ABS(CUR-PREV)) 74,75,75
74    PREV=CUR
      SONE=(SONE+CUR)/4.
      GO TO 71
75    R=CUR/3
      IF (Z-105.) 44,76,44
   44 IF (D-105.) 76,55,76
C
```

```
C     DENSITY FOR 90%Z%105
C
76    DENS=3.46E-9*183.*EM*EXP(-R/FK)/(TZ*28.878)
      DL=ALOG10(DENS)
      PAR=AV*DENS/EM
      AN=ALOG10(QN*EM*PAR/28.96)
      AA=ALOG10(QA*EM*PAR/28.96)
      AHE=ALOG10(QHE*EM*PAR/28.96)
      AO=ALOG10(2.*PAR*(1.-EM/28.96))
      AO2=ALOG10(PAR*(EM*(1.+QO2)/28.96-1.))
      AH=-0.
      RETURN
C
C     TEMPERATURE AND MEAN MOLECULAR WEIGHT AT Z=105 KM
C
   40 Z3=105.
      TZ3=TX+T1*(Z3'125.)+T3*(Z3-125)**3+T4*(Z3-125)**4
      ZM3=B(1)+B(2)* 5.+B(3)* 25.+B(4)* 125.+B(5)* 5.**4.+B(6)* 5.**5.
     1+B(7)* 5.**6.
      D=105.
      GO TO 70
C
C     DENSITY  AT Z=105 KM
C
55    DEN1=3.46E-9*183.*ZM3*EXP(-R/FK)/(TZ3*28.878)
      PAR=AV*DEN1/ZM3
      DI(1)=QN*ZM3*PAR/28.96
      DI(2)=PAR*(ZM3*(1.+QO2)/28.96-1.)
      DI(3)=2.*PAR*(1.-ZM3/28.96)
      DI(4)=QA*ZM3*PAR/28.96
      DI(5)=QHE*ZM3*PAR/28.96
      IF(Z-125.) 56,56,90
56    CONTINUE
C
C     INTEGRATION OF EQ. 6 FOR DENSITY ABOVE 105 KM
C
      R=0.
      D1=125.
      A1=105.
  400 CONTINUE
      FA1=9.80665/((1.+A1/6.356766E+3)**2)
      FA1=FA1/(TX+T1*(A1-125.)+T3*(A1-125.)**3+T4*(A1-125.)**4)
      FD1=9.80665/((1.+D1/6.356766E+3)**2)
      IF(D1-125.) 45,45,50
   45 FD1=FD1/(TX+T1*(D1-125.)+T3*(D1-125.)**3+T4*(D1-125.)**4)
      GO TO 51
50    FD1=FD1/(TX+A2*ATAN(T1*(D1-125.)*(1.+4.5E-6*(D1-125.)**2.5)/A2))
      TZ=TX+A2*ATAN(T1*(Z-125.)*(1.+4.5E-6*(Z-125.)**2.5)/A2)
51    N=0
      NINT = 1
      PREV=0
      SONE=(D1-A1)*(FA1+FD1)/2.
81    N=N+1
      IF (N-M) 82,82,85
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82    NINT = 2 * NINT
      STWO=0.
      DEL=(D1-A1)/FLOAT(NINT)
      DO 83 I=1,NINT,2
      X1=A1+DEL*FLOAT(I)
      FX1=9.80665/((1.+X1/6.356766E+3)**2)
      IF(X1-125.) 46,46,52
   46 FX1=FX1/(TX+T1*(X1-125.)+T3*(X1-125.)**3+T4*(X1-125.)**4)
      GO TO 83
52    FX1=FX1/(TX+A2*ATAN(T1*(X1-125.)*(1.+4.5E-6*(X1-125.)**2.5)/A2))
83    STWO=STWO+FX1
      CUR=SONE+4.*DEL*STWO
      IF (EPS*ABS(CUR)-ABS(CUR-PREV)) 84,85,85
84    PREV=CUR
      SONE=(SONE+CUR)/4.
      GO TO 81
85    R=CUR/3.+R
      IF(A1.EQ.125.) GO TO 430
      D1=Z
      A1=125.
      GO TO 400
  430 CONTINUE
C
C     DENSITY ABOVE 105 KM
C
      DO 41  I=1,5
      DIT(I)=DI(I)*(TZ3/TZ)**(1.+ALPHA(I))*EXP(-EI(I)*R/FK)
   41 CONTINUE
      DENS=0
      DO 42 I=1,6
      DENS=DENS+EI(I)*DIT(I)/AV
42    CONTINUE
C
C     MEAN MOLECULAR WEIGHT FOR Z 105 KM
C
      EM=DENS*AV/(DIT(1)+DIT(2)+DIT(3)+DIT(4)+DIT(5)+DIT(6))
C
C     LOG DENSITY
C
      DL=ALOG10(DENS)
      AN =ALOG10(DIT(1))
      AO2=ALOG10(DIT(2))
      AO =ALOG10(DIT(3))
      AA =ALOG10(DIT(4))
      AHE=ALOG10(DIT(5))
      IF(Z-500.) 47,48,48
   47 DIT(6)=10.**(-6)
   48 AH=ALOG10(DIT(6))
      AN =AMAX1(-0., AN)
      AO2=AMAX1(-0.,AO2)
      AO =AMAX1(-0., AO)
      AA =AMAX1(-0., AA)
      AHE=AMAX1(-0.,AHE)
      AH =AMAX1(-0., AH)
      RETURN
C
C     TEMPERATURE AND DENSITY AT Z=500 KM
C
90    S=TX+A2*ATAN(T1*375.*(1.+4.5E-6*375.**2.5)/A2)
      DI(6)=10.**(73.13-39.4*ALOG10(S)+5.5*ALOG10(S)*ALOG10(S))
      D1=500.
      IF(Z-500.) 49,60,60
C
C     INTEGRATION OF EQ. 6 FOR DENSITY FOR Z 125 KM
C
   49 A1=Z
   60 FA1=9.80665/((1.+A1/6.356766E+3)**2)
      FA1=FA1/(TX+A2*ATAN(T1*(A1-125.)*(1.+4.5E-6*(A1-125.)**2.5)/A2))
      D1=Z
      IF(Z-500.) 61,62,62
   61 D1=500.
   62 FD1=9.80665/((1.+D1/6.356766E+3)**2)
      FD1=FD1/(TX+A2*ATAN(T1*(D1-125.)*(1.+4.5E-6*(D1-125.)**2.5)/A2))
      N=0
      NINT = 1
      PREV=0
      SONE=(D1-A1)*(FA1+FD1)/2.
91    N=N+1
      IF (N-M) 92,92,95
92    NINT = 2 * NINT
      STWO=0.
      DEL=(D1-A1)/FLOAT(NINT)
      DO 93 I=1,NINT,2
      X1=A1+DEL*FLOAT(I)
      FX1=9.80665/((1.+X1/6.356766E+3)**2)
      FX1=FX1/(TX+A2*ATAN(T1*(X1-125.)*(1.+4.5E-6*(X1-125.)**2.5)/A2))
93    STWO=STWO+FX1
      CUR=SONE+4.*DEL*STWO
      IF (EPS*ABS(CUR)-ABS(CUR-PREV)) 94,95,95
94    PREV=CUR
      SONE=(SONE+CUR)/4.
      GO TO 91
95    R=CUR/3.
C
C     TEMPERATURE AT Z 500 KM
C
      TZ=TX+A2*ATAN(T1*(Z-125.)*(1.+4.5E-6*(Z-125.)**2.5)/A2)
      IF(Z-500.) 63,64,64
   63 R=-R
C
C     DENSITY OF HYDROGEN FOR Z 500 KM
C
   64 DIT(6)=DI(6)*(S/TZ)*EXP(-EI(6)*R/FK)
      GO TO 56
      END
      SUBROUTINE JACCH(Z,PHIR,THET,PH,DH,TH)
      COMMON/COMJAC/XLAT,XLONG,SDA,SHA,DY,R,T,EM
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NNCOP,DD,XNJD,PHI1,PHI,
     .             NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,
     $ M , IDA, IYR, H1, PHI1R,THET1R,G,RI,H,CLAT,CLON ,F10,F10B,AP,
     .   IHR,MIN,NMORE,DX,HL,VL,DZ
C
C      JACCH CALCULATES THE PRESSURE, DENSITY, AND TEMPERATURE AT A
C      POINT IN SPACE ABOVE 90 KM FOR A PARTICULAR TIME
C
C      INPUT
C      Z = HEIGHT IN KM
C      PHIR = LATITUDE IN RADIANS
C      THET = LONGITUDE IN DEGREES  (0 TO 360 DEGREES TURNING WESTWARD)
C      F10 = SOLAR RADIO NOISE FLUX (XE - 22 WATTS/M**2)
C      F10B = 81-DAY AVERAGE F10
C      AP = GEOMAGNETIC INDEX
C      M  = MONTH (FOR YEARLY MEAN VARIABLES M IS SET TO 13)
C      IDA = DAY OF MONTH
C      IYR = YEAR
C      IHR = HOUR OF DAY  (UNIVERSAL TIME)
C      MIN = MINUTE  (UNIVERSAL TIME)
C      XMJD = MEAN JULIAN DAY  (SET EQUAL TO ZERO FOR ANNUAL MEAN)
C      DG = DAY NUMBER WITH RESPECT TO JAN 0 OF YEAR IYR
C
C      OUTPUT
C      PH = PRESSURE IN UNITS OF NT/M**2
C      DH = DENSITY IN UNITS OF KG/M**3
C      TH = TEMPERATURE IN KELVIN DEGREES
C
C      DD = DAY NUMBER WITH RESPECT TO JAN 1 OF YEAR IYR
C
C      REPLACEMENT OF SUBROUTINE VARIABLES TO INSURE NO CHANGES IN THEM
C
      R = 0.31
      XLAT = PHIR
      XLONG = THET
      IF (M.EQ.13) GO TO 50
C
C      CALCULATE SOLAR DEC. AND HOUR ANGLE
C
      CALL TME
C
C      EXOSPHERIC TEMPERATURE
C
      CALL TINF
      GO TO 75
   50 T = 1000.0
C
C      TEMPERATURE, MOLECULAR WEIGHT, AND DENSITY WITHOUT SEASONAL
C         VARIATIONS
C
   75 CALL JAC(Z,TH,DH)
      IF (M.EQ.13) GO TO 300
      YDA = 365.0
      J1 = MOD(IYR,4)
      IF (J1.EQ.0) YDA = 366.0
      C1 = SIN((360. / YDA) * 0.0174532925 * (DD + 100.0))              JACC  58
      IF (PHIR) 80,70,80                                                JACC  59
   70 C2 = 0.0                                                          JACC  60
      GO TO 90                                                          JACC  61
   80 C2 = (SIN(PHIR) ** 2) * (PHIR / ABS(PHIR))                        JACC  62
C                                                                       JACC  63
C     DENSITY WITH SEASONAL VARIATIONS                                  JACC  64
C                                                                       JACC  65
   90 Z90 = Z - 90.0                                                    JACC  66
      DLRHO = 0.02 * Z90 * EXP(-0.045 * Z90) * C1 * C2                  JACC  67
      DH = DH * EXP(DLRHO)                                              JACC  68
C                                                                       JACC  69
C     MOLECULAR WEIGHT WITH SEASONAL VARIATION                          JACC  70
C                                                                       JACC  71
      IF (Z - 120.0) 100,100,150                                        JACC  72
  100 EM = EM + 0.006 * Z90 * C1                                        JACC  73
      GO TO 250                                                         JACC  74
  150 IF (Z - 230.0) 200,250,250                                        JACC  75
  200 DEM = EXP(-0.02424 * Z90) * (0.0316 * Z90 - 0.0002257 * Z90 * Z90)JACC  76
      EM = EM + DEM * C1*0.5                                            JACC  77
C                                                                       JACC  78
C     TEMPERATURE WITH SEASONAL VARIATIONS                              JACC  79
C                                                                       JACC  80
  250 IF (Z-260.0) 270,300,300                                          JACC  81
  270 Z110 = Z - 110.0                                                  JACC  82
      DTH = -2.291753 * Z110 + 0.02154336 * Z110*Z110- 4.1766671E-05 *  JACC  83
     * (Z110 ** 3)                                                      JACC  84
      DTH = EXP(-0.290655 * SQRT(ABS(Z110)))* DTH                       JACC  85
      TH = TH +(DTH * C1 * C2 *TH) / 100.0                              JACC  86
C                                                                       JACC  87
C     DENSITY IN METRIC UNITS AND PRESSURE CALCULATED                   JACC  88
C                                                                       JACC  89
  300 DH = DH * 1000.0                                                  JACC  90
      PH =((DH * 8.31432 * TH) / EM) * 1000.0                           JACC  91
      RETURN                                                            JACC  92
      END                                                               JACC  93
      SUBROUTINE NORMAL(D1,D2)                                          NORM   1
C.....PRODUCES 2 RANDOM NUMBERS, D1, D2, PICKED FROM A NORMAL DIST.     NORM   2
C     WITH ZERO MEAN AND UNIT VARIANCE                                  NORM   3
      REAL L                                                            NORM   4
   50 X = RAND(0)                                                       NORM   5
      Y = 2*RAND(0) - 1                                                 NORM   6
      XX = X**2                                                         NORM   7
      YY = Y**2                                                         NORM   8
      S = XX + YY                                                       NORM   9
      IF (S-1) 51,51,50                                                 NORM  10
   51 L = SQRT(-2*ALOG(RAND(0)))/S                                      NORM  11
      D1 = (XX-YY)*L                                                    NORM  12
      D2 = 2*X*Y*L                                                      NORM  13
      RETURN                                                            NORM  14
      END                                                               NORM  15
      SUBROUTINE PDTUV (PSP, DSP, TSP, CLAT, CLON, IH, PS, DS, TS,      PDTU   1
     * DPX, DPY, DTX, DTY,DP2X,DP2Y,DPXY)                               PDTU   2
C.....INTERPOLATES STATIONARY PERTURBATIONS ON LATITUDE AND LONGITUDE   PDTU   3
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C        AT HEIGHT IN                                                   PDTU   4
      DIMENSION PSP(8,10,12),DSP(8,10,12),TSP(8,10,12)                  PDTU   5
      IF (IN.LT.52) GO TO 10                                            PDTU   6
      IF (IN.GT.84) GO TO 20                                            PDTU   7
C     HEIGHT INDEX K                                                    PDTU   8
      K = ((IN+4)/8) - 4                                                PDTU   9
      GO TO 30                                                          PDTU  10
   10 K = (IN-20)/10                                                    PDTU  11
      GO TO 30                                                          PDTU  12
   20 K = 8                                                             PDTU  13
   30 XLON = CLON                                                       PDTU  14
      IF (CLON.LT.10.) XLON = 360. + CLON                               PDTU  15
C     LOWER LONGITUDE INDEX J                                           PDTU  16
      J = INT((XLON + 20.)/30.)                                         PDTU  17
C.....DLON - RELATIVE LONGITUDE DEVIATION FROM CORNER REFERENCE LOCATIONPDTU  18
      DLON = (XLON - 30.*J + 20.)/30.                                   PDTU  19
C     UPPER LONGITUDE INDEX JP                                          PDTU  20
      JP = J+1                                                          PDTU  21
      IF (JP.GT.12) JP=1                                                PDTU  22
C     LOWER LATITUDE INDEX I                                            PDTU  23
      I = INT((CLAT + 110.)/20.)                                        PDTU  24
C      UPPER LATITUDE INDEX IP                                          PDTU  25
      IP = I+1                                                          PDTU  26
      IF (IP.GT.10) IP=10                                               PDTU  27
C.....DLAT - RELATIVE LATITUDE DEVIATION FROM CORNER REFERENCE LOCATION PDTU  28
      DLAT = (CLAT-20.*I + 110.)/20.                                    PDTU  29
C     PRESSURE LAT-LON INTERPOLATION                                    PDTU  30
      PS=PSP(K,I,J)+(PSP(K,IP,J)-PSP(K,I,J))*DLAT+(PSP(K,I,JP)-PSP(K,I,JPDTU  31
     1))*DLON+(PSP(K,IP,JP)-PSP(K,I,JP)-PSP(K,IP,J)+PSP(K,I,J))*DLAT*   PDTU  32
     2DLON                                                              PDTU  33
C     DENSITY LAT-LON INTERPOLATION                                     PDTU  34
      DS=DSP(K,I,J)+(DSP(K,IP,J)-DSP(K,I,J))*DLAT+(DSP(K,I,JP)-DSP(K,I,JPDTU  35
     1))*DLON+(DSP(K,IP,JP)-DSP(K,I,JP)-DSP(K,IP,J)+DSP(K,I,J))*DLAT*   PDTU  36
     2DLON                                                              PDTU  37
C     TEMPERATURE LAT-LON INTERPOLATION                                 PDTU  38
      TS=TSP(K,I,J)+(TSP(K,IP,J)-TSP(K,I,J))*DLAT+(TSP(K,I,JP)-TSP(K,I,JPDTU  39
     1))*DLON+(TSP(K,IP,JP)-TSP(K,I,JP)-TSP(K,IP,J)+TSP(K,I,J))*DLAT*   PDTU  40
     2DLON                                                              PDTU  41
C.....DPX - DP/DX FOR GEOSTROPHIC WINDS                                 PDTU  42
      DPX = (PSP(K,I,J) - PSP(K,I,JP)) / 6.                             PDTU  43
      DPX = DPX + ((PSP(K,IP,J) - PSP(K,IP,JP))/6. - DPX)*DLAT          PDTU  44
C.....DPY - DP/DY FOR GEOSTROPHIC WINDS                                 PDTU  45
      DPY=(PSP(K,IP,J)-PSP(K,I,J))/4.                                   PDTU  46
      DPY = DPY + ((PSP(K,IP,JP) - PSP(K,I,JP))/4. - DPY)*DLON          PDTU  47
C.....DTX - DT/DX FOR THERMAL WINDS                                     PDTU  48
      DTX = (TSP(K,I,J) - TSP(K,I,JP)) / 6.                             PDTU  49
      DTX = DTX + ((TSP(K,IP,J) - TSP(K,IP,JP))/6. - DTX)*DLAT          PDTU  50
C.....DTY - DT/DY FOR THERMAL WINDS                                     PDTU  51
      DTY = (TSP(K,IP,J) - TSP(K,I,J)) / 4.                             PDTU  52
      DTY = DTY + ((TSP(K,IP,JP) - TSP(K,I,JP))/4. - DTY)*DLON          PDTU  53
      IF (IP.GT.9) GO TO 90                                             PDTU  54
      DPXY = (PSP(K,IP,J) - PSP(K,IP,JP) - PSP(K,I,J) + PSP(K,I,JP))/24.PDTU  55
      JX = J - 1                                                        PDTU  56
      IF (JX.LT.1) JX = JX + 12                                         PDTU  57
      IY = I -  1                                                       PDTU  58
      DP2X = (PSP(K,I,JX) - PSP(K,I,JP))/6.                             PDTU  59
      DP2X = DP2X + ((PSP(K,IP,JX) - PSP(K,IP,JP))/6. - DP2X)*DLAT      PDTU  60
      DP2Y = (PSP(K,IP,J) - PSP(K,IY,J))/4.                             PDTU  61
      DP2Y = DP2Y + ((PSP(K,IP,JP) - PSP(K,IY,JP))/4.- DP2Y)*DLON       PDTU  62
      RETURN                                                            PDTU  63
90    DP2X = 0.                                                         PDTU  64
      DP2Y = 0.                                                         PDTU  65
      DPXY = 0.                                                         PDTU  66
      RETURN                                                            PDTU  67
      END                                                               PDTU  68
      SUBROUTINE PERTRB                                                 PERT   1
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG;NNCOP,DD,XMJD,PHI1,PHI,NSAME,     PERT   2
     *PL1,DL1,TL1,SPL1,SDL1:STL1,UL1,VL1,SUL1,SVL1,MN,IDA,IYR,          PERT   3
     1PH,PLAT,                                                          PERT   4
     * PLON,G,R,CH,CLAT,CLON,F10,F10B,AP,IHR,MIN,NMORE,DX,HL,VL,DZ,     PERT   5
     2B,EPS,IOPP,LOOK,IET,FLAT,PS1,DS1,TS1,US1,VS1,SPS1,SDS1,           PERT   6
     3STS1,SUS1,SVS1,UDS1,VDS1,UDL1,VDL1,UDS2,VDS2,UDL2,VDL2            PERT   7
      COMMON /COMPER/SP2,SD2,ST2,P2,D2,T2,U2,V2,SU2,SV2,CP,             PERT   8
     1PS2,DS2,TS2,US2,VS2,                                              PERT   9
     2PL2,DL2,TL2,UL2,VL2,                                              PERT  10
     3SPS2,SDS2,STS2,SUS2,SVS2,                                         PERT  11
     4SPL2,SDL2,STL2,SUL2,SVL2                                          PERT  12
      COMMON/WINCOM/ DUM(11),T                                          PERT  13
      DLON = ABS(CLON-PLON)                                             PERT  14
      PI = 3.1415927                                                    PERT  15
      IF(DLON.GT.PI) DLON = 2.*PI - DLON                                PERT  16
      DX  =      R*SQRT((CLAT-PLAT)**2 + (COS(CLAT)*(DLON     ))**2)    PERT  17
C.....DX IS HORIZONTAL DISTANCE BETWEEN POSITIONS PLAT,PLON AND CLAT,CLOPERT  18
      AH = 900.                                                         PERT  19
      BH = 6.                                                           PERT  20
C     HORIZONTAL WAVELENGTH, KM                                         PERT  21
      HLL= AH + BH*CH                                                   PERT  22
      DPHI = (90. - ABS(PHI1))**2                                       PERT  23
      DHGT = 0.22 + 0.00258*(SQRT(ABS(CH)**3))                          PERT  24
      IF (DHGT.GT.5.) DHGT = 5.                                         PERT  25
      VDS = (11.0 - 2.102E-4*DPHI)*DHGT                                 PERT  26
      VTS = (3.0 + 5.146E-4*DPHI)*DHGT                                  PERT  27
      VUS = (6.2 - 3.615E-4*DPHI)*DHGT                                  PERT  28
      VDL = (20.7 - 1.346E-3*DPHI)*DHGT                                 PERT  29
      VTL = 7.3*DHGT                                                    PERT  30
      VUL = (31.2 - 3.503E-3*DPHI)*DHGT                                 PERT  31
      HLS = 20. + .0125*CH*CH                                           PERT  32
      IF(HLS.GT.400.) HLS = 400.                                        PERT  33
      HLS = (DX/HLS)**2                                                 PERT  34
      HLL = (DX/HLL)**2                                                 PERT  35
      RDS=SQRT(HLS+(DZ/VDS)**2)                                         PERT  36
      IF(RDS.LE.100.)GO TO 10                                           PERT  37
      RDS=0.                                                            PERT  38
      GO TO 20                                                          PERT  39
10     RDS=1./EXP(RDS)                                                  PERT  40
20    RTS=SQRT(HLS+(DZ/VTS)**2)                                         PERT  41
      IF(RTS.LE.100.)GO TO 30                                           PERT  42
      RTS=0.                                                            PERT  43
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      GO TO 40                                                          PERT  44
30    RTS=1./EXP(RTS)                                                   PERT  45
40    RVS=SQRT(HLS+(DZ/VUS)**2)                                         PERT  46
      IF(RVS.LE.100.)GO TO 50                                           PERT  47
      RVS=0.                                                            PERT  48
      GO TO 60                                                          PERT  49
50    RVS=1./EXP(RVS)                                                   PERT  50
60    RDL=SQRT(HLL+(DZ/VTL)**2)                                         PERT  51
      IF(RDL.LE.100.)GO TO 70                                           PERT  52
      RDL=0.                                                            PERT  53
      GO TO 80                                                          PERT  54
70    RDL=1./EXP(RDL)                                                   PERT  55
80    RTL=SQRT(HLL+(DZ/VTL)**2)                                         PERT  56
      IF(RTL.LE.100.)GO TO 90                                           PERT  57
      RTL=0.                                                            PERT  58
      GO TO 100                                                         PERT  59
90    RTL=1./EXP(RTL)                                                   PERT  60
100   RVL=SQRT(HLL+(DZ/VUL)**2)                                         PERT  61
      IF(RVL.LE.100.)GO TO 110                                          PERT  62
      RVL=0.                                                            PERT  63
      GO TO 120                                                         PERT  64
110   RVL=1./EXP(RVL)                                                   PERT  65
120   CONTINUE                                                          PERT  66
      CALL CORLAT(AS,BS,CS,DS,ES,FS,GS,HS,AIS,AJS,AKS,SPS1,SPS2,SDS1,   PERT  67
     1 SDS2,STS1,STS2,SUS1,SUS2,SVS1,SVS2,UDS1,UDS2,VDS1,VDS2,RDS,RTS,  PERT  68
     2RVS)                                                              PERT  69
      CALL CORLAT(AL,BL,CL,DL,EL,FL,GL,HL,AIL,AJL,AKL,SPL1,SPL2,SDL1,   PERT  70
     1 SDL2,STL1,STL2,SUL1,SUL2,SVL1,SVL2,UDL1,UDL2,VDL1,VDL2,          PERT  71
     2RDL,RTL,RVL)                                                      PERT  72
      CALL NORMAL(ZD,ZT)                                                PERT  73
      DS2=AS*DS1+BS*ZD                                                  PERT  74
      TS2=CS*TS1+DS*DS2+ES*ZT                                           PERT  75
      PS2=DS2+TS2                                                       PERT  76
      CALL NORMAL(ZD,ZT)                                                PERT  77
      US2=FS*US1+GS*DS2+HS*ZD                                           PERT  78
      VS2=AIS*VS1+AJS*DS2+AKS*ZT                                        PERT  79
      CALL NORMAL(ZD,ZT)                                                PERT  80
      DL2=AL*DL1+BL*ZD                                                  PERT  81
      TL2=CL*TL1+DL*DL2+EL*ZT                                           PERT  82
      PL2=DL2+TL2                                                       PERT  83
      CALL NORMAL(ZD,ZT)                                                PERT  84
      UL2=FL*UL1+GL*DL2+HL*ZD                                           PERT  85
      VL2=AIL*VL1+AJL*DL2+AKL*ZT                                        PERT  86
      P2=PS2+PL2                                                        PERT  87
      D2=DS2+DL2                                                        PERT  88
      T2=TS2+TL2                                                        PERT  89
      U2=US2+UL2                                                        PERT  90
      V2=VS2+VL2                                                        PERT  91
      UDL1=UDL2                                                         PERT  92
      UDS1=UDS2                                                         PERT  93
      VDL1=VDL2                                                         PERT  94
      VDS1=VDS2                                                         PERT  95
      RETURN                                                            PERT  96
      END                                                               PERT  97
      SUBROUTINE PHASE(D1,X1,D2,X2,D,X)
      PER = 870.
      IF (X2-X1) 20,10,20
   10 D = D1
      RETURN
   20 DA = D1
      DB = D2
      PER2 = PER/2.
      IF(ABS(DB-DA).LE.PER2)GO TO 30
      IF (DA.LT.PER2) DA = DA + PER
      IF (DB.LT.PER2) DB = DB + PER
   30 DA = DA + (DB - DA)*(X - X1)/(X2 - X1)
      IF (DA.GT.PER) DA = DA - PER
      IF(DA.LT.0.)DA=DA+PER
      D = DA
      RETURN
      END
      SUBROUTINE QBOGEN
C.....COMPUTES QBO VALUES PQ,DQ,TQ,UQ,VQ AT HEIGHT H, LATITUDE PHI
C        ON JULIAN DAY XMJD FROM ARRAYS OF AMPLITUDES PAQ,DAQ,TAQ,
C        UAQ,VAQ AND PHASES PDQ,DDQ,TDQ,UDQ,VDQ.
      COMMON/IOTEMP/IOTEM1,IOTEM2,IU6,NMCOP,DDD,XMJD,PHI1,PHI,
     .          NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,
     $ NN, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,AP,
     .   IHR,MIN,NMORE,DX,HL,VL,DZ
      COMMON/PDTCOM/IU4,MONTH,IOPR,PG(18,19),TG(18,19),DG(18,19)
     . ,PSP(8,10,12)
     . ,DSP(8,10,12),TSP(8,10,12),PAQ(17,5),DAQ(17,5),TAQ(17,5),
     . PDQ(17,5),DDQ(17,5),TDQ(17,5),PR(20,10),DR(20,10),TR(20,10),
     .UAQ(17,5),VAQ(17,5),UDQ(17,5),VDQ(17,5),UR(25,10),VR(25,10)
     . ,PQ,DQ,TQ,UQ,VQ
     . ,PA,DA,TA,UA,VA,IOPQ
      IF (XMJD.GT.0.AND.IOPQ.EQ.1) GO TO 10
C     SETS QBO VALUES TO ZERO FOR ANNUAL MEAN
      PQ =0.
      DQ=0.
      TQ=0.
      UQ=0.
      VQ=0.
      RETURN
C     LOWER HEIGHT INDEX
   10 IH = INT((H-5.)/5.)
      IF (IH.LT.1) IH=1
C     UPPER HEIGHT INDEX
      IP = IH + 1
      IF (IP.GT.17) IP = 17
      PHA = ABS(PHI)
C    LOWER LATITUDE INDEX

      JL = INT((  PHA    + 10.)/20.)
C     UPPER LATITUDE INDEX
      JP = JL + 1
      IF (JL.LE.0) JL=1
      IF (JP.GT.5) JP=5
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C     JULIAN DAY FOR JAN 0, 1966                                        QBOG  38
      XMJD0 = 2439126                                                   QBOG  39
C     TIME RELATIVE TO JAN 0, 1966                                      QBOG  40
      TMJD = XMJD-XMJD0                                                 QBOG  41
C     2*PI/PERIOD,PERIOD = 870 DAYS                                     QBOG  42
      PER = 870.                                                        QBOG  43
      TP = 6.2831853/PER                                                QBOG  44
C     LOWER HEIGHT                                                      QBOG  45
      HI = 5. + 5.*IH                                                   QBOG  46
C     LOWER LATITUDE                                                    QBOG  47
      PHIJ = 20.*JL - 10.                                               QBOG  48
C     UPPER LATITUDE                                                    QBOG  49
      PHIP = 20.*JP-10.                                                 QBOG  50
C.....INTERPOLATES QBO P,D,T AMPLITUDE ON LATITUDE AT LOWER HEIGHT       QBOG  51
      CALL INTERZ(PAQ(IH,JL),DAQ(IH,JL),TAQ(IH,JL),PHIJ,PAQ(IH,JP),     QBOG  52
     1DAQ(IH,JP),TAQ(IH,JP),PHIP,PA1,DA1,TA1,PHA)                       QBOG  53
C     UPPER HEIGHT                                                      QBOG  54
      HP = 5.+5.*IP                                                     QBOG  55
C.....INTERPOLATES QBO P,D,T AMPLITUDE ON LATITUDE AT UPPER HEIGHT       QBOG  56
      CALL INTERZ(PAQ(IP,JL),DAQ(IP,JL),TAQ(IP,JL),PHIJ,PAQ(IP,JP),     QBOG  57
     2DAQ(IP,JP),TAQ(IP,JP),PHIP,PA2,DA2,TA2,PHA)                       QBOG  58
C.....INTERPOLATES QBO P,D,T AMPLITUDE ON HEIGHT AT LATITUDE PHI         QBOG  59
      CALL INTERZ(PA1,DA1,TA1,HI,PA2,DA2,TA2,HP,PA,DA,TA,H)             QBOG  60
C.....INTERPOLATES QBO P,D,T,U,V PHASE ON LATITUDE AND HEIGHT            QBOG  61
      CALL PHASE(PDQ(IH,JL),PHIJ,PDQ(IH,JP),PHIP,PD1,PHA)               QBOG  62
      CALL PHASE(DDQ(IH,JL),PHIJ,DDQ(IH,JP),PHIP,DD1,PHA)               QBOG  63
      CALL PHASE(TDQ(IH,JL),PHIJ,TDQ(IH,JP),PHIP,TD1,PHA)               QBOG  64
      CALL PHASE(PDQ(IP,JL),PHIJ,PDQ(IP,JP),PHIP,PD2,PHA)               QBOG  65
      CALL PHASE(DDQ(IP,JL),PHIJ,DDQ(IP,JP),PHIP,DD2,PHA)               QBOG  66
      CALL PHASE(TDQ(IP,JL),PHIJ,TDQ(IP,JP),PHIP,TD2,PHA)               QBOG  67
      CALL PHASE(PD1,HI,PD2,HP,PD,H)                                    QBOG  68
      CALL PHASE(DD1,HI,DD2,HP,DD,H)                                    QBOG  69
      CALL PHASE(TD1,HI,TD2,HP,TD,H)                                    QBOG  70
      CALL PHASE(UDQ(IH,JL),PHIJ,UDQ(IH,JP),PHIP,UD1,PHA)               QBOG  71
      CALL PHASE(VDQ(IH,JL),PHIJ,VDQ(IH,JP),PHIP,VD1,PHA)               QBOG  72
      CALL PHASE(UDQ(IP,JL),PHIJ,UDQ(IP,JP),PHIP,UD2,PHA)               QBOG  73
      CALL PHASE(VDQ(IP,JL),PHIJ,VDQ(IP,JP),PHIP,VD2,PHA)               QBOG  74
      CALL PHASE(UD1,HI,UD2,HP,UD,H)                                    QBOG  75
      CALL PHASE(VD1,HI,VD2,HP,VD,H)                                    QBOG  76
C.....INTERPOLATES QBO WIND AMPLITUDE ON LATITUDE AT LOWER HEIGHT        QBOG  77
      CALL INTERW(UAQ(IH,JL),VAQ(IH,JL),PHIJ,UAQ(IH,JP),VAQ(IH,JP),     QBOG  78
     5PHIP,UA1,VA1,PHA)                                                 QBOG  79
C.....INTERPOLATES QBO WIND AMPLITUDES ON LATITUDE AT UPPER HEIGHT       QBOG  80
      CALL INTERW(UAQ(IP,JL),VAQ(IP,JL),PHIJ,UAQ(IP,JP),VAQ(IP,JP),     QBOG  81
     6PHIP,UA2,VA2,PHA)                                                 QBOG  82
C.....INTERPOLATES QBO WIND AMPLITUDES ON HEIGHT AT LATITUDE PHI         QBOG  83
      CALL INTERW(UA1,VA1,HI,UA2,VA2,HP,UA,VA,H)                        QBOG  84
C.....EVALUATES QBO VALUES FROM INTERPOLATED AMPLITUDES AND PHASES       QBOG  85
      PQ=PA*COS(TP*(TMJD-PD))                                           QBOG  86
      DQ=DA*COS(TP*(TMJD-DD))                                           QBOG  87
      TQ=TA*COS(TP*(TMJD-TD))                                           QBOG  88
      UQ=UA*COS(TP*(TMJD-UD))                                           QBOG  89
      VQ=VA*COS(TP*(TMJD-VD))                                           QBOG  90
      RETURN                                                            QBOG  91
      END                                                               QBOG  72
      FUNCTION RAND(X0)                                                 RAND   1
C.....PRODUCES A RANDOM NUMBER FROM A UNIFORM DIST. FROM 0 TO +1        RAND   2
      INTEGER X0                                                        RAND   3
      IF (X0.NE.0) X = X0/262144.                                       RAND   4
      X = X*509                                                         RAND   5
      X = X - INT(X)                                                    RAND   6
      RAND = X                                                          RAND   7
      RETURN                                                            RAND   8
      END                                                               RAND   9
      SUBROUTINE RIG                                                    RIG    1
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NNCOP,DD,XMJD,PHI1,PHI,           RIG    2
     .           NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,RIG    3
     $ MN, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,AP,    RIG    4
     .   IHR,MIN,NMORE,DX,HL,VL,DZ,B,EPS                                RIG    5
     1RP1S,RD1S,RT1S,RU1S,RV1S,SP1S,SD1S,ST1S,SU1S,SV1S,                RIG    6
     2UDS1,VDS1,UDL1,VDL1,UDS2,VDS2,UDL2,VDL2                           RIG    7
C.....GRAVITY G AT H, LATITUDE PHIR (RADIANS)                           RIG    8
C.....RADIUS RI FROM CENTER OF EARTH TO HEIGHT H                        RIG    9
C.....B = POLAR EARTH RADIUS, EPS = ECCENTRICITY                        RIG   10
      CPHI2 = COS(PHIR) ** 2                                            RIG   11
C      EARTH RADIUS                                                     RIG   12
      RI = B / SQRT(1. - EPS * CPHI2)                                   RIG   13
C     C2PHI = COS(2*PHIR)                                               RIG   14
      C2PHI = 2. * CPHI2 - 1.                                           RIG   15
C     C4PHI = COS(4*PHIR)                                               RIG   16
      C4PHI = 8. * CPHI2 * (CPHI2 - 1.) + 1.                            RIG   17
C.....G AT SURFACE                                                      RIG   18
      G = 9.80616 * (1. - 0.0026373 * C2PHI + 0.0000059 * C2PHI * C2PHI)RIG   19
C.....EFFECTIVE RADIUS                                                  RIG   20
      RE = 2. * G / (3.085462E-3 + C2PHI * 2.27E-6 - C4PHI * 2.E-9)     RIG   21
C      G AT HEIGHT H                                                    RIG   22
      G = G / (1. + (H / RE)) ** 2                                      RIG   23
C      RADIUS AT HEIGHT H                                               RIG   24
      RI = RI + H                                                       RIG   25
      END                                                               RIG   26
      SUBROUTINE RTERP(H,PHI,PR,DR,TR,P,D,T)                            RTER   1
C.....COMPUTES RANDOM PERTURBATION STANDARD DEVIATIONS P,D,T AT         RTER   2
C        HEIGHT H (KM), LATITUDE PHI(DEGREES) FROM SIGMA ARRAYS         RTER   3
C        PR,DR,AND TR                                                   RTER   4
      DIMENSION PR(20,10),DR(20,10),TR(20,10)                           RTER   5
C.....I = LOWER HEIGHT INDEX                                            RTER   6
      IF (H.LT.95.) I = INT((H-20.)/5.)                                 RTER   7
      IF (H.GE.95.) I = 14 + INT((H-80.)/20.)                           RTER   8
      IP = I+1                                                          RTER   9
      IF (IP.GT.20) IP = 20                                             RTER  10
C      LOWER LATITUDE INDEX                                             RTER  11
      J = INT((PHI + 110.)/20.)                                         RTER  12
      JP = J+1                                                          RTER  13
      IF (JP.GT.10) JP=10                                               RTER  14
      IF (I.GT.14) GO TO 10                                             RTER  15
C     LOWER HEIGHT FOR PR,TR,DR  ARRAYS                                 RTER  16
      Z1=5.*I+20.                                                       RTER  17
      GO TO 20                                                          RTER  18
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   10 Z1=20.*(I-10)
   20 IF (IP.GT.14) GO TO 30
C     UPPER HEIGHT FOR PR,DR,TR ARRAYS
      Z2=5.*IP+20.
      GO TO 40
   30 Z2=20.*(IP-10)
   40 PHI1=-110.+20.*J
      PHI2=-110.+20.*JP
C.....INTERPOLATE ON LATITUDE AT LOWER HEIGHT
      CALL INTERZ(PR(I,J),DR(I,J),TR(I,J),PHI1,PR(I,JP),DR(I,JP),
     1            TR(I,JP),PHI2,P1,D1,T1,PHI)
C.....INTERPOLATE ON LATITUDE AT UPPER HEIGHT
      CALL INTERZ(PR(IP,J),DR(IP,J),TR(IP,J),PHI1,PR(IP,JP),DR(IP,JP),
     1            TR(IP,JP),PHI2,P2,D2,T2,PHI)
C.....INTERPOLATION ON HEIGHT USING LATITUDE INTERPOLATED VALUES
      CALL INTERZ(P1,D1,T1,Z1,P2,D2,T2,Z2,P,D,T,H)
      RETURN
      END
      SUBROUTINE RTRAN
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG
      COMMON/COTRAN/NDATA(19),I1,I2,I3,I4(10),I5
C.....ENTRY POINT TO READ STATIONARY PERTURBATION DATA, AND
C        RANDOM PERTURBATION DATA IN SETUP
      IWHERE=2H.
      READ(IUG,100,END=3) NDATA
100   FORMAT(A2,19I7)
      RETURN
      ENTRY RTRAN1
C.....ENTRY POINT TO READ GROVES DATA IN SETUP
      IWHERE=2H1.
      READ(IUG,100,END=3) NDATA
      I1=NDATA(1)
      I2=NDATA(2)
      I3=NDATA(3)
      I5=NDATA(14)
      DO 1 I=1,10
    1 I4(I)=NDATA(I+3)
      RETURN
      ENTRY RTRAN2
C.....ENTRY POINT TO READ QBO PARAMETERS IN SETUP
      IWHERE=2H2.
      READ(IUG,100,END=3) NDATA
      I1=NDATA(1)
      I3=NDATA(2)
      DO 2 I=1,10
    2 I4(I)=NDATA(2+I)
      RETURN
    3 WRITE(6,200) IUG,IWHERE
  200 FORMAT('1  PREMATURE END-OF-FILE FOUND ON UNIT ',I2/
     1'0  CALLED FROM SUBROUTINE RTRAN',A2)
      STOP
      END
      SUBROUTINE SCIMOD(MPOP)
C.....COMPUTES VALUES P,D,T,U,V AND SHEAR DUH,DVH FROM INPUT AND
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C        ARRAYS IN COMMON PDTCOM.  INPUT TO SCIMOD IS%
C        G = GRAVITY AT POSITION        RI = RADIUS AT HEIGHT H
C        PHIR = LATITUDE (RADIANS)      THETR = LONGITUDE (RADIANS)
C        F10 = F10.7 SOLAR FLUX         F10B = MEAN F10.7 FLUX
C        AP = SOLAR-GEOMAGNETIC A SUB P INDEX
C        MN/IDA/IYR = DATA (IYR = FULL YEAR-1900)
C        IHR%MIN = TIME                 H1 = PREVIOUS HEIGHT
C        PHI1R = PREVIOUS LATITUDE      THET1R = PREVIOUS LONGITUDE
C        RP1,RD1,RT1 = PREVIOUS RANDOM PERTURBATIONS
C        SP1,SD1,ST1 = PREVIOUS RANDOM STANDARD DEVIATIONS (SIGMAS)
C        RU1,RV1 = PREVIOUS RANDOM WINDS
C        SU1,SV1 = PREVIOUS RANDOM WIND SIGMAS
       COMMON/IPRTP/ IPRT
       COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI,
     .NSAME,RP1L,RD1L,RT1L,SP1L,SD1L,ST1L,RU1L,RV1L,SU1L,SV1L,
     $ MN, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,AP,
     .   IHR,MIN,NMORE,DX,HL,VL,DZ,B,EPS,IOPP,LOOK,IET,FLAT,
     1RP1S,RD1S,RT1S,RU1S,RV1S,SP1S,SD1S,ST1S,SU1S,SV1S,
     2UDS1,VDS1,UDL1,VDL1,UDS2,VDS2,UDL2,VDL2
       COMMON/PDTCOM/IU4,MONTH,IOPR,PG(18,19),TG(18,19),DG(18,19)
     . ,PSP(8,10,12)
     . ,DSP(8,10,12),TSP(8,10,12),PAQ(17,5),DAQ(17,5),TAQ(17,5),
     . PDQ(17,5),DDQ(17,5),TDQ(17,5),PR(20,10),DR(20,10),TR(20,10),
     .UAQ(17,5),VAQ(17,5),UDQ(17,5),VDQ(17,5),UR(25,10),VR(25,10),  PQ
     . ,DQ,TQ,UQ,VQ,PQA,DQA,TQA,UA,VA,IOPQ,
     1PLP(25,10),DLP(25,10),TLP(25,10),
     2ULP(25,10),VLP(25,10),UDL(25,10),
     3VDL(25,10),UDS(25,10),VDS(25,10)
       COMMON /C4/ GLAT(16),GLON(16),NG,P4D(16,26),D4D(16,26),T4D(16,26),
     .  SP4(16,26),SD4(16,26),ST4(16,26),THET1,THET,DUMMY
       COMMON/COMPER/SPH,SDH,STH,PRH,DRH,TRH,URH,VRH,SUH,SVH,CP,
     1PRHS,DRHS,TRHS,URHS,VRHS,PRHL,DRHL,TRHL,URHL,VRHL,
     2SPHS,SDHS,STHS,SUHS,SVHS,SPHL,SDHL,STHL,SUHL,SVHL
        COMMON/WINCOM/DH,FCORY,DX5,DY5,DPX,DPY,DPXX,DPXY,DPYY,UGH,VGH,
     $    TH,DTX,DTY,DUH,DVH,PH ,UPRE,VPRE,DUPRE,DVPRE
       COMMON/CHK/PCK(4,4,3),DCK(4,4,3),ND(2)
       COMMON/CHIC/LA(4,4),NB(2),IWSYM,UCOEF(14,9),VCOEF(14,9)
C       FACTOR FOR RADIANS TO DEGREES
      FAC = 57.2957795
      IWSYM = ' '
      IF(NPOP.NE.0) GO TO 6
      UPRE=0.
      VPRE=0.
      DUPRE=0.
      DVPRE=0.
    6 PQ=0.
      DQ=0.
      TQ=0.
      PRH=0.
      DRH=0.
      TRH=0.
      URH=0.
      VRH=0.
      UQ=0.
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      VQ=0.
      PQA=0.
      DQA=0.
      TQA=0.
      UA=0.
      VA=0.
      PSH=0.
      DSH=0.
      TSH=0.
      MONTH=MN
C     PRESENT LATITUDE, DEG
      PHI = PHIR*FAC
C     PRESENT LONGITUDE, DEG
      THET = THETR*FAC
C     PREVIOUS LATITUDE, DEG
      PHI1 = PHI1R*FAC
C     PREVIOUS LONGITUDE, DEG
      THET1 = THET1R*FAC
C.....FCORY = NORTH COMPONENT CORIOLIS FACTOR TIMES DISTANCE FOR
C        5 DEGREES OF LATITUDE
      DY5 = 5000.*RI/FAC
      DX5 = DY5*COS(PHIR)
      FCORY = DY5*SIN(PHIR)/(120.*FAC)
C.....IN JACCHIA OR MIXED GROVES-JACCHIA HEIGHT RANGE
    8 IF(H.GT.90.0) GO TO 10
C.....IN 4-D DATA HEIGHT RANGE
      IF (H.LE.25.0) GO TO 500
C       IN GROVES OR MIXED GROVES 4D HEIGHT RANGE
      GO TO 200
C.....IN MIXED JACCHIA-GROVES RANGE, NEED TO FAIR DATA
 10   IF (H.LT.115.) GO TO 20
C.....FOLLOWING IS THE PURE JACCHIA HEIGHT RANGE SECTION
C.....JACCHIA VALUES AT CURRENT POSITION
      CALL JACCH(H,PHIR,THET,PH,DH,TH)
      PHIN = PHIR + 5. / FAC
      THETE = THET - 5.
C.....JACCHIA VALUES AT CURRENT POSITION+5 DEGREES LAT, FOR DP/DY AND
C        DT/DY
      CALL JACCH(H,PHIN,THET,PHN,DHN,THN)
C.....JACCHIA VALUES AT CURRENT POSITION-5 DEGREES LON, FOR DP/DX AND
C        DT/DX
      CALL JACCH(H,PHIR,THETE,PHE,DHE,THE)
C      DP/DY FOR GEOSTROPHIC WIND
      DPY=PHN-PH
C      DP/DX FOR GEOSTROPHIC WIND
      DPX=PHE-PH
C      DT/DX FOR THERMAL WIND SHEAR
      DTX = THE - TH
C      DT/DY FOR THERMAL WIND SHEAR
      DTY = THN - TH
C      CHANGE NOTATION FOR OUTPUT
      PGH=PH
      DGH=DH
      TGH=TH
      CALL WIND
      UH = UGH
      VH = VGH
      HB = H + 5.
      CP = 7.*PH/(2.*DH*TH)
      CALL JACCH(HB,PHIR,THET,PB,DB,TB)
      DTZ = (TB - TH)/5000.
C.....VERTICAL MEAN WIND
      WGH = -CP*(UH*DTX/DX5 + VH*DTY/DY5)/(G + CP*DTZ + UH*DUH+VH*DVH)
C       GO TO RANDOM PERTURBATIONS SECTION
      GO TO 800
C.....FOLLOWING IS THE MIXED JACCHIA-GROVES HEIGHT RANGE SECTION
C       LOWER HEIGHT INDEX
 20   IHA = 5*(INT(H)/5)
C        UPPER HEIGHT INDEX
      IHB = IHA + 5
C     LOWER HEIGHT FOR INTERPOLATION
      HA = IHA*1.
C     UPPER HEIGHT FOR INTERPOLATION
      HB = IHB*1.
C.....JACCHIA VALUES AT LOWER HEIGHT, CURRENT LAT-LON
      CALL JACCH(HA,PHIR,THET,PJA,DJA,TJA)
      PHIN = PHIR + 5. / FAC
      THETE = THET - 5.
C.....JACCHIA VALUES AT LOWER HEIGHT, CURRENT LAT-LON+5 DEGREES
C         LAT, FOR DP/DY AND DT/DY
      CALL JACCH(HA,PHIN,THET,PJN,DJN,TJN)
C.....JACCHIA VALUES AT LOWER HEIGHT, CURRENT LAT-LON-5 DEGREES
C         LON, FOR DP/DX, AND DT/DX
      CALL JACCH(HA,PHIR,THETE,PJE,DJE,TJE)
C     JACCHIA DP/DY AT LOWER HEIGHT
      DPXJA=PJE-PJA
C      JACCHIA DP/DY AT LOWER HEIGHT
      DPYJA=PJN-PJA
C      JACCHIA DT/DX AT LOWER HEIGHT
      DTXJA = TJE - TJA
C      JACCHIA DT/DY AT LOWER HEIGHT
      DTYJA = TJN - TJA
C.....JACCHIA VALUES AT UPPER HEIGHT, CURRENT LAT-LON
      CALL JACCH(HB,PHIR,THET,PJB,DJB,TJB)
      PHIN = PHIR + 5. / FAC
      THETE=THETE-5
C.....JACCHIA VALUES AT UPPER HEIGHT, CURRENT LAT/LON+5 DEGREES
C         LAT, FOR DP/DY AND DT/DY
      CALL JACCH(HB,PHIN,THET,PJN,DJN,TJN)
C.....JACCHIA VALUES AT UPPER HEIGHT, CURRENT LAT-LON-5 DEGREES
C         LON, FOR DP/DX AND DT/DX
      CALL JACCH(HB,PHIR,THETE,PJE,DJE,TJE)
C     JACCHIA DP/DX FOR GEOSTROPHIC WINDS
      DPXJB = PJE - PJB
C      JACCHIA DP/DY FOR GEOSTOPHIC WINDS
      DPYJB = PJN - PJB
C     JACCHIA DT/DX FOR THERMAL WIND SHEAR
      DTXJB = TJE - TJB
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C      JACCHIA DT/DY FOR THERMAL WIND SHEAR
      DTYJB = TJN - TJB
C.....GROVES AT LOWER HEIGHT, TO BE FAIRED WITH JACCHIA
      CALL GTERP(IHA,PHI,PGA,DGA,TGA,PG,DG,TG,DPYGA,DTYGA,DP2YGA)
C.....GROVES AT UPPER HEIGHT, TO BE FAIRED WITH JACCHIA
      CALL GTERP(IHB,PHI,PGB,DGB,TGB,PG,DG,TG,DPYGB,DTYGB,DP2YGB)
C.....FAIRED RESULTS AT LOWER HEIGHT
      CALL FAIR(PGA,DGA,TGA,PJA,DJA,TJA,IHA,P1,D1,T1,      DPYGA,
     $ DPXJA,DPYJA,DPXA,DPYA,       DTYGA,DTXJA,DTYJA,DTXA,DTYA)
C.....FAIRED RESULTS AT UPPER HEIGHT
      CALL FAIR(PGB,DGB,TGB,PJB,DJB,TJB,IHB,P2,D2,T2,      DPYGB,
     $DPXJB,DPYJB,DPXB,DPYB,       DTYGB,DTXJB,DTYJB,DTXB,DTYB)
C.....HEIGHT INTERPOLATION ON FAIRED P,D,T
      CALL INTER2(P1,D1,T1,HA,P2,D2,T2,HB,PH,DH,TH,H)
C.....HEIGHT INTERPOLATION ON FAIRED DP/DX,DP/DY
      CALL INTERW(DPXA,DPYA,HA,DPXB,DPYB,HB,DPX,DPY,H)
C.....HEIGHT INTERPOLATION ON FAIRED DT/DX,DT/DY
      CALL INTERW(DTXA,DTYA,HA,DTXB,DTYB,HB,DTX,DTY,H)
C.....EASTWARD COMPONENT OF GEOSTROPHIC WIND
      CALL WIND
C      CHANGE OF VARIABLES FOR OUTPUT
      PGH=PH
      DGH=DH
      TGH=TH
      UH = UGH
      VH = VGH
      CP = 7.*PH/(2.*DH*TH)
      DTZ = (T2 - T1)/5000.
C.....VERTICAL MEAN WIND
      WGH = -CP*(UH*DTX/DX5 + VH*DTY/DY5)/(G + CP*DTZ + UH*DUH + VH*DVH)
C      GO TO RANDOM PERTURBATIONS SECTION
      GO TO 800
C.....THE FOLLOWING SECTION IS FOR GROVES OR MIXED GROVES 4D HEIGHTS
C      UPPER HEIGHT INDEX
  200 IHGB = 5*(INT(H)/5) + 5
      IF (IHGB.GT.90) IHGB=90
C     UPPER HEIGHT
      HGB = IHGB*1.
C.....GROVES AT UPPER HEIGHT
      CALL GTERP(IHGB,PHI,PGB,DGB,TGB,PG,DG,TG,DPYGB,DTYGB,DP2YGB)
C.....UPPER STATIONARY PERTURBATION HEIGHT = 40
      IF (H.LT.40.0) GO TO 210
C.....UPPER STATIONARY PERTURBATION HEIGHT = 90
      IF (H.GT.84.0) GO TO 220
C.....UPPER STATIONARY PERTURBATION HEIGHT = 52,60,68,76,OR 84
      IHSB = 8*((INT(H) + 4)/8) + 4
C.....UPPER STATIONARY PERTURBATION HEIGHT = 52
      IF (IHSB.LT.52.0) IHSB = 52
      GO TO 230
  210 IHSB = 10*(INT(H)/10) + 10
      GO TO 230
  220 IHSB = 90
C     UPPER STATIONARY PERTURBATION HEIGHT
  230 HSB = IHSB*1.
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C.....STATIONARY PERTURBATIONS AT UPPER HEIGHT                          SCIN 219
      CALL PDTUV(PSP,DSP,TSP,PHI,THET,IHSB,PSB,DSB,TSB,DPXSB,DPYSB,     SCIN 220
     $ DTXSB,DTYSB,DP2XSB,DP2YSB,DPXYSB)                                SCIN 221
C      MIXED GROVES 4D SECTION                                          SCIN 222
      IF (H.LT.30.0) GO TO 300                                          SCIN 223
C     LOWER HEIGHT INDEX                                                SCIN 224
      IHGA = IHGB - 5                                                   SCIN 225
C     LOWER HEIGHT INDEX                                                SCIN 226
      HGA = IHGA*1.                                                     SCIN 227
C.....GROVES AT LOWER HEIGHT                                            SCIN 228
      CALL GTERP(IHGA,PHI,PGA,DGA,TGA,PG,DG,TG,DPYGA,DTYGA,DP2YGA)      SCIN 229
C.....LOWER STATIONARY PERTURBATION HEIGHT = 30                         SCIN 230
      IF (H.LT.40.0) GO TO 240                                          SCIN 231
C.....LOWER STATIONARY PERTURBATION HEIGHT = 52,60,68,76, OR 84         SCIN 232
      IHSA = 8*((INT(H) + 4)/8) - 4                                     SCIN 233
C.....LOWER STATIONARY PERTURBATIONS HEIGHT = 40                        SCIN 234
      IF (IHSA.LT.40.0) IHSA = 40                                       SCIN 235
      GO TO 250                                                         SCIN 236
  240 IHSA = 30                                                         SCIN 237
C     LOWER STATIONARY PERTURBATION HEIGHT                              SCIN 238
 250  HSA = IHSA*1.                                                     SCIN 239
C.....STATIONARY PERTURBATIONS AT LOWER HEIGHT                          SCIN 240
      CALL PDTUV(PSP,DSP,TSP,PHI,THET,IHSA,PSA,DSA,TSA,DPXSA,DPYSA,     SCIN 241
     $ DTXSA,DTYSA,DP2XSA,DP2YSA,DPXYSA)                                SCIN 242
C.....GROVES VALUES HEIGHT INTERPOLATIONS                               SCIN 243
      CALL INTER2(PGA,DGA,TGA,HGA,PGB,DGB,TGB,HGB,PGH,DGH,TGH,H)        SCIN 244
C.....STATIONARY PERTURBATION HEIGHT INTERPOLATION                      SCIN 245
      CALL INTERZ(PSA,DSA,TSA,HSA,PSB,DSB,TSB,HSB,PSH,DSH,TSH,H)        SCIN 246
C     QUASI-BIENNIAL VALUES                                             SCIN 247
      CALL QBOGEN                                                       SCIN 248
C.....HEIGHT INTERPOLATION OF GROVES DP/DY, DT/DY, AND D2P/DY2          SCIN 249
      CALL INTERZ(DPYGA,DTYGA,DP2YGA,HGA,DPYGB,DTYGB,DP2YGB,HGB,DPYG,   SCIN 250
     $   DTYG,DP2YG,H)                                                  SCIN 251
C.....HEIGHT INTERPOLATION OF STATIONARY PERTURBATION DP/DX AND DP/DY   SCIN 252
      CALL INTERW(DPXSA,DPYSA,HSA,DPXSB,DPYSB,HSB,DPXS,DPYS,H)          SCIN 253
C.....HEIGHT INTERPOLATION OF STATIONARY PERTURBATION DT/DX AND DT/DY   SCIN 254
      CALL INTERW(DTXSA,DTYSA,HSA,DTXSB,DTYSB,HSB,DTXS,DTYS,H)          SCIN 255
C.....HEIGHT INTERPOLATION OF STATIONARY PERTURBATION D2P/DX2,D2P/DY2,  SCIN 256
C               AND D2P/DXDY                                            SCIN 257
      CALL INTERZ(DP2XSA,DP2YSA,DPXYSA,HSA,DP2XSB,DP2YSB,DPXYSB,HSB,    SCIN 258
     $       DP2XS,DP2YS,DPXYS,H)                                       SCIN 259
C.....UNPERTURBED (MONTHLY MEAN) VALUES FOR OUTPUT                      SCIN 260
      TGH = TGH * (1. + TSH)                                            SCIN 261
      PGH = PGH * (1. + PSH)                                            SCIN 262
      DGH = DGH * (1. + DSH)                                            SCIN 263
C     TOTAL DT/DX                                                       SCIN 264
      DTX =          DTXS * TGH                                         SCIN 265
C     TOTAL DT/DY                                                       SCIN 266
      DTY = TGH*DTYS + DTYG*(1. + TSH + DTYS)                           SCIN 267
C     TOTAL DP/DX                                                       SCIN 268
      DPX =          DPYS * PGH                                         SCIN 269
C     TOTAL DP/DY                                                       SCIN 270
      DPY = PGH*DPYS + DPYG*(1. + PSH + DPYS)                           SCIN 271
C     D2P/DX2                                                           SCIN 272
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      DPXX = PGH*(2.*DPXS - DP2XS)                                      SCIM 273
      DPYY = PGH*(2.*DPYS - DP2YS) +  (2.*DPYG - DP2YG)*(1. +PSH+DPYS)  SCIM 274
     $     - (DPYG - DP2YG)*DP2YS                                       SCIM 275
C     D2P/DXDY                                                          SCIM 276
      DPXY = (PGH + DPYG)*DPXYS + DPYG*DPXS                             SCIM 277
C.....UNPERTURBED VALUES PLUS QBO PERTURBATIONS                         SCIM 278
      PH = (1. + PQ) * PGH                                              SCIM 279
      DH = DGH * (1. + DQ)                                              SCIM 280
      TH = (1. + TQ) * TGH                                              SCIM 281
      CALL WIND                                                         SCIM 282
C     GEOSTROPHIC WIND PLUS QBO WIND PERTURBATIONS                      SCIM 283
      UH=UGH+UQ                                                         SCIM 284
      VH=VGH+VQ                                                         SCIM 285
      CP = 7.*PGH/(2.*DGH*TGH)                                          SCIM 286
      DTZ = (TGB*(1.+TSB) - TGA*(1.+TSA))/5000.                         SCIM 287
C.....VERTICAL MEAN WIND                                                SCIM 288
      WGH=-CP*(UGH*DTX/DX5+VGH*DTY/DY5)/(G+CP*DTZ+VGH*DUH+VGH*DVH)      SCIM 289
C      GO TO RANDOM PERTURBATIONS SECTION                               SCIM 290
      GO TO 800                                                         SCIM 291
C.....THE FOLLOWING IS THE MIXED GROVES 4D SECTION                      SCIM 292
C.....GENERATE GRID OF 4D PROFILES IF PREVIOUS HEIGHT GE 30             SCIM 293
300   IF (H1.GE.30..OR.LOOK.EQ.1) CALL GEN4D                            SCIM 294
      IHCK = 24                                                         SCIM 295
      DO 310 KND = 1,3                                                  SCIM 296
      IKND = IHCK + KND                                                 SCIM 297
      IF (IKND.GT.26)IKND=26                                            SCIM 298
      DO 310 IND = 1,4                                                  SCIM 299
      DO 310 JND = 1,4                                                  SCIM 300
      PCK(IND,JND,KND) = P4D(4*(IND-1)+JND,IKND)                        SCIM 301
      DCK(IND,JND,KND) = D4D(4*(IND-1)+JND,IKND)                        SCIM 302
 310  CONTINUE                                                          SCIM 303
      CALL CHECK                                                        SCIM 304
C.....LAT-LON INTERPOLATION OF 4D DATA AT 25 KM                         SCIM 305
      CALL INTER4(          PHI,THET,25,   P4D,D4D,T4D,P4A,D4A,T4A,     SCIM 306
     $ DPX4,DPY4,DTX4,DTY4,DPXXA,DPYYA,DPXYA)                           SCIM 307
C      GROVES PLUS STATIONARY PERTURBATIONS                             SCIM 308
      PB = PGB*(1. + PSB)                                               SCIM 309
C      P,D,T                                                            SCIM 310
      DB = DGB*(1. + DSB)                                               SCIM 311
      TB = TGB*(1. + TSB)                                               SCIM 312
      DPXB = PGB*DPXSB                                                  SCIM 313
      DPYB = PGB*DPYSB + DPYGB*(1. + PSB + DPYSB)                       SCIM 314
      DPXXB = PGB*(2.*DPXSB - DP2XSB)                                   SCIM 315
      DPYYB = PGB*(2.*DFYSB - DP2YSB) + (2.*DPYGB - DP2YGB)*            SCIM 316
     $  (1. + PSB + DPYSB) - (DPYGB - DP2YGB)*DP2YSB                     SCIM 317
      DPXYB = (PGB + DPYGB)*DPXYSB + DPYGB*DPXSB                        SCIM 318
      DTXB = TGB*DTXSB                                                  SCIM 319
      DTYB = TGB*DTYSB + DTYGB*(1. + TSB + DTYSB)                       SCIM 320
C.....HEIGHT INTERPOLATION BETWEEN 4D AT 25 AND GROVES AT UPPER HEIGHT  SCIM 321
C       DP/DX AND DP/DY                                                 SCIM 322
      CALL INTERW(DPX4,DPY4,25.,DPXB,DPYB,HSB,DPX,DPY,H)                SCIM 323
C.....HEIGHT INTERPOLATION BETWEEN 4D AT 25 AND GROVES AT UPPER HEIGHT  SCIM 324
C       P,D,T                                                           SCIM 325
      CALL INTER2(P4A,D4A,T4A,25.,PB,DB,TB,HGB,PGH,DGH,TGH,H)           SCIM 326
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C.....HEIGHT INTERPOLATION BETWEEN 4D AT 25 AND GROVES AT UPPER HEIGHT
C         DT/DX AND DT/DY
      CALL INTERW(DTX4,DTY4,25.,DTXB,DTYB,HSB,DTX,DTY,H)
C.....HEIGHT INTERPOLATION BETWEEN 4D AT 25 KM AND GROVES AT UPPER
C     HEIGHT D2P/DX2, D2P/DY2, AND D2P/DXDY
      CALL INTERZ(DPXXA,DPYYA,DPXYA,25.,DPXXB,DPYYB,DPXYB,HGB,DPXX,
     $     DPYY,DPXY,H)
      IF (IOPQ.EQ.2) GO TO 350
C     QUASI BIENNIAL PERTURBATIONS
      CALL QBOGEN
C     ADD QBO PERTURBATIONS TO P,D,T
  350 PH=PGH*(1.+PQ)
      DH=DGH*(1.+DQ)
      TH=TGH*(1.+TQ)
      CALL WIND
C     ADD QBO WIND PERTURBATIONS
      UH=UGH+UQ
      VH=VGH+VQ
      CP = 7.*PGH/(2.*DGH*TGH)
      DTZ = (TB - T4A)/(1000.*(HGB - 25.))
C.....VERTICAL MEAN WIND
      WGH=-CP*(UGH*DTX/DX5+VGH*DTY/DY5)/(G+CP*DTZ+UGH*DUH+VGH*DVH)
C     GO TO RANDOM PERTURBATIONS SECTION
 2000 FORMAT(' LATITUDE',/16F8.3)
 2001 FORMAT(' LONGITUDE',/16F8.3,/' PRESSURE')
 2002 FORMAT(1X,I2,16F8.0)
      GO TO 800
  500 IF (H.GE.0.0) GO TO 510
      IF (H.LT.-0.015) GO TO 505
C     IF -15 METER LE H LT 0 , H IS SET TO 0
      H = 0.
      GO TO 510
C     NO MORE COMPUTATIONS TO BE MADE IF HEIGHT LT -5 M
  505 NMORE = 0
       RETURN
C.....GENERATE GRID OF 4D PROFILES IF PREVIOUS HEIGHT GE 30
510   IF (H1.GE.30..OR.LOOK.EQ.1) CALL GEN4D
C      LOWER HEIGHT INDEX
       IHA=INT(H)
C      LOWER HEIGHT INDEX
       HA = IHA*1.
      IWSX = IWSYM
      IHCK=IHA-1
      DO 511 KND=1,3
      IKND = IHCK + KND
      IF (IKND.LT.1)IKND = 1
      IF (IKND.GT.26)IKND = 26
      DO 511 IND=1,4
      DO 511 JND = 1,4
      PCK(IND,JND,KND)=P4D(4*(IND-1)+JND,IKND)
      DCK(IND,JND,KND)=D4D(4*(IND-1)+JND,IKND)
511   CONTINUE
      CALL CHECK
C      UPPER HEIGHT INDEX
```

```
      IHB = IHA + 1
      IF(IHB.LE.25) GO TO 513
      IHA=24
      HA=24.
      IHB=25
C        UPPER HEIGHT
  513 HB = IHB*1.
C.....LAT-LON INTERPOLATION OF 4D VALUES AT UPPER HEIGHT
  515 CALL INTER4(           PHI,THET,IHB,   P4D,D4D,T4D,PB,DB,TB,
     $ DPX4B,DPY4B,DTX4B,DTY4B,DPXXB,DPYYB,DPXYB)
      IF(IHA.EQ.0.AND.PB*DB*TB.LE.0.)GO TO 520
      GO TO 540
  520 IHB=IHB+1
C.....LOOP TO FIND LOWEST VALID HEIGHT
      HB=HB+1.
      GO TO 515
  540 IF(IHA.GT.0)CALL INTER4(           PHI,THET,IHA,   P4D,D4D,T4D,
     1PA,DA,TA,DPX4A,DPY4A,DTX4A,DTY4A,DPXXA,DPYYA,DPXYA)
      IF(IWSYM.EQ.'*')IWSX = IWSYM
      IF(IHA.EQ.0.OR.(PA*DA*TA.LE.0.AND.IHA.LT.10.AND.PB*DB*TB.GT.0.))
     1GO TO 550
      GO TO 600
C.....LAT-LON INTERPOLATION OF 4D VALUES AT LOWER HEIGHT
  550 CALL INTER4(           PHI,THET,0,   P4D,D4D,T4D,
     .PA,DA,TA,DPX4A,DPY4A,DTX4A,DTY4A,DPXXA,DPYYA,DPXYA)
      IF(IWSYM.EQ.'*')IWSX = IWSYM
      IF(TA-TB)560,570,560
  560 TZ=(TA-TB)/ALOG(TA/TB)
      GO TO 575
  570 TZ=TA
C ...COMPUTES HEIGHT OF SURFACE
  575 HA=HB+0.28705*TZ*ALOG(PB/PA)/G
      IF(H.GT.HA-.04) GO TO 600
      PH=0.
      DH=0.
      TH=0.
      PGH=0.
      DGH=0.
      TGH=0.
      GO TO 800
C.....HEIGHT INTERPOLATION OF P,D,T
  600 CALL INTER2(PA,DA,TA,HA,PB,DB,TB,HB,PGH,DGH,TGH,H)
C.....HEIGHT INTERPOLATION OF DP/DX AND DP/DY
      CALL INTERW(DPX4A,DPY4A,HA,DPX4B,DPY4B,HB,DPX,DPY,H)
C.....HEIGHT INTERPOLATION OF DT/DX AND DT/DY
      CALL INTERW(DTX4A,DTY4A,HA,DTX4B,DTY4B,HB,DTX,DTY,H)
C.....HEIGHT INTERPOLATION OF D2P/DX2, D2P/DY2, AND D2P/DXDY
      CALL INTERZ(DPXXA,DPYYA,DPXYA,HA,DPXXB,DPYYB,DPXYB,HB,DPXX,DPYY,
     $DPXY,H)
C        CHANGE OF NOTATION FOR OUTPUT
      PH = PGH
      DH = DGH
      TH = TGH
      IF(PH*DH*TH.LE.0.) GO TO 800
      CALL WIND
C      CHANGE OF NOTATION FOR OUTPUT
      UH = UGH
      VH = VGH
      CP = 7.*PGH/(2.*DGH*TGH)
      DTZ = (TB - TA)/(1000.*(HB - HA))
C.... VERTICAL MEAN WIND
      WGH = -CP*(UGH*DTX/DX5 + VGH*DTY/DY5)/(G+CP*DTZ+UH*DUH+VH*DVH)
C     QBO=0 IF H LT 10
      IF (H.LT.10.) GO TO 800
      IF (IOPQ.EQ.2) GO TO 650
C     COMPUTES QUASI BIENNIAL PERTURBATIONS
      CALL QBOGEN
C     ADDS QBO PERTURBATIONS TO P,D,T
  650 PH=PGH*(1.+PQ)
      DH=DGH*(1.+DQ)
      TH=TGH*(1.+TQ)
C     ADDS QBO WIND PERTURBATIONS TO U,V
      UH=UGH+UQ
      VH=VGH+VQ
C.....THE FOLLOWING IS THE RANDOM PERTURBATIONS SECTION
C.....NO RANDOM PERTURBATIONS IF IOPR GT 1
  800 CONTINUE
      IF(H.GT.30) GO TO 512
      IF(IPRT.NE.0.OR.IWSYM.NE.'*') GO TO 512
      WRITE(6,2000) (GLAT(I),I=1,16)
      WRITE(6,2001) (GLON(I),I=1,16)
      DO 504 I=1,26
      IH=I-1
      WRITE(6,2002) IH,(P4D(J,I),J=1,16)
  504 CONTINUE
      IPRT=IPRT+1
  512 CONTINUE
      IF (IOPR.GT.1) GO TO 830
C.....INTERPOLATES RANDOM WIND MAGNITUDES TO HEIGHT H, LATITUDE PHI
      CALL INTRUV(UR,VR,H,PHI,SUH,SVH)
      CALL INTRUV(PLP,DLP,H,PHI,PLPH,DLPH)
      CALL INTRUV(TLP,DLP,H,PHI,TLPH,DLPH)
      CALL INTRUV(ULP,VLP,H,PHI,ULPH,VLPH)
      CALL INTRUV(UDL,VDL,H,PHI,UDL2,VDL2)
      CALL INTRUV(UDS,VDS,H,PHI,UDS2,VDS2)
      SUHL=SQRT(ULPH*ABS(SUH))
      SUHS=SQRT((1.-ULPH)*ABS(SUH))
      SVHL=SQRT(VLPH*ABS(SVH))
      SVHS=SQRT((1.-VLPH)*ABS(SVH))
      SUH = SQRT(ABS(SUH))
      SVH = SQRT(ABS(SVH))
C.....IF H LE 25 USE 4D DATA RANDOM P,D,T SIGMAS
      IF (H.LE.25.) GO TO 810
C.....INTERPOLATE PR,DR,TR ARRAYS TO GET P,D,T SIGMAS AT HEIGHT H,
C         LATITUDE PHI
      CALL RTERP(H,PHI,PR,DR,TR,SPH,SDH,STH)
      GO TO 820
C.....LAT-LON INTERPOLATION ON P,D,T SIGMAS AT LOWER HEIGHT
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  810 CALL INTER4(          PHI,THET,IHA,   SP4,SD4,ST4,PA,DA,TA,
     $ DPX,DPY,DTX,DTY,DPXX,DPYY,DPXY)
C.....LAT-LON INTERPOLATION ON P,D,T SIGMSA AT UPPER HEIGHT
      CALL INTER4(          PHI,THET,IHB,   SP4,SD4,ST4,PB,DB,TB,
     $ DPX,DPY,DTX,DTY,DPXX,DPYY,DPXY)
C.....HEIGHT INTERPOLATION OF SIGMAS
      CALL INTERZ(PA,DA,TA,   HA,PB,DB,TB,   HB,SPH,SDH,STH,H)
      IF(PH*DH*TH.LE.0.) GO TO 825
C.....HEIGHT DISPLACEMENT BETWEEN PREVIOUS AND CURRENT POSITION
  820 DZ = H1 - H
      SPHL=SQRT(PLPH*ABS(SPH))
      SPHS=SQRT((1.-PLPH)*ABS(SPH))
      SDHL=SQRT(DLPH*ABS(SDH))
      SDHS=SQRT((1.-DLPH)*ABS(SDH))
      STHL=SQRT(TLPH*ABS(STH))
      STHS=SQRT((1.-TLPH)*ABS(STH))
      SPH = SQRT(ABS(SPH))
      SDH = SQRT(ABS(SDH))
      STH = SQRT(ABS(STH))
C.....COMPUTES HORIZONTAL DIXPLACEMENT DX BETWEEN PREVIOUS AND CURRENT
C        POSITION, HORIZONTAL SCALE HL, AND VERTICAL SCALE VL
C.....COMPUTES PERTURBATION VALUES PRH,DRH,TRH,URH AND VRH
      CALL PERTRB
C     ADDS RANDOM PERTURBATIONS TO PH,DH,TH
      PH = PH*(1. + PRH)
      DH = DH*(1. + DRH)
      TH = TH*(1. + TRH)
C     ADDS RANDOM WINDS TO UH,VH
      UH=UH+URH
      VH=VH+VRH
C.....SETS PREVIOUS RANDOM PERTURBATION IN P,D,T TO CURRENT
C        PERTURBATIONS, FOR NEXT CYCLE
  825 RP1S= PRHS
      RD1S= DRHS
      RT1S= TRHS
      RP1L=PRHL
      RD1L=DRHL
      RT1L=TRHL
C.....SETS PREVIOUS MAGNITUDES FO CURRENT VALUES, FOR NEXT CYCLE
      SP1S=SPHS
      SD1S= SDHS
      ST1S=STHS
      SP1L=SPHL
      SD1L=SDHL
      ST1L=STHL
C.....SETS PREVIOUS WIND PERTURBATION VALUES TO CURRENT VALUES,
C        FOR NEXT CYCLE
      RU1S=URHS
      RV1S=VRHS
      RU1L=URHL
      RV1L=VRHL
C.....SETS PREVIOUS WIND PERTURBATION MAGNITUDES TO CURRENT VALUES,
C        FOR NEXT CYCLE
      SU1S=SUHS
      SV1S=SVHS                                                         SCIN 543
      SU1L=SUHL                                                         SCIN 544
      SV1L=SVHL                                                         SCIN 545
C.....SETS PREVIOUS HEIGHT TO CURRENT HEIGHT, FOR NEXT CYCLE            SCIN 546
  830 H1 = H                                                            SCIN 547
C.....SETS PREVIOUS LATITUDE TO CURRENT LATITUDE, FOR NEXT CYCLE        SCIN 548
      PHI1R=PHIR                                                        SCIN 549
C.....SETS PREVIOUS LONGITUDE TO CURRENT LONGITUDE, FOR NEXT CYCLE      SCIN 550
      THET1R=THETR                                                      SCIN 551
C     SETS NMORE TO COMPUTE MORE DATA ON NEXT CYCLE                     SCIN 552
      NMORE = 1                                                         SCIN 553
C.....NO MORE DATA IF P, D, OR T LEQ 0                                  SCIN 554
      IF(PH*DH*TH.LE.0.) RETURN                                         SCIN 555
      CALL STDATM(H,TS,PS,DS)                                           SCIN 556
      IF ((PS*DS*TS).GT.0.) GO TO 870                                   SCIN 557
      PGHP=0.                                                           SCIN 558
      DGHP=0.                                                           SCIN 559
      TGHP=0.                                                           SCIN 560
      PHP=0.                                                            SCIN 561
      DHP=0.                                                            SCIN 562
      THP=0.                                                            SCIN 563
      GO TO 880                                                         SCIN 564
  870 PGHP=100.*(PGH-PS)/PS                                             SCIN 565
      DGHP=100.*(DGH-DS)/DS                                             SCIN 566
      TGHP=100.*(TGH-TS)/TS                                             SCIN 567
      PHP=100.*(PH-PS)/PS                                               SCIN 568
      DHP=100.*(DH-DS)/DS                                               SCIN 569
      THP=100.*(TH-TS)/TS                                               SCIN 570
C     CONVERTS QBO P,D,T TO PERCENT                                     SCIN 571
  880 PQ=100.*PQ                                                        SCIN 572
      DQ=100.*DQ                                                        SCIN 573
      TQ=100.*TQ                                                        SCIN 574
C     CONVERTS RANDOM P,D,T TO PERCENT                                  SCIN 575
      PRH=100.*PRH                                                      SCIN 576
      DRH=100.*DRH                                                      SCIN 577
      TRH=100.*TRH                                                      SCIN 578
      PRHS=100.*PRHS                                                    SCIN 579
      DRHS=100.*DRHS                                                    SCIN 580
      TRHS=100.*TRHS                                                    SCIN 581
      PRHL=100.*PRHL                                                    SCIN 582
      DRHL=100.*DRHL                                                    SCIN 583
      TRHL=100.*TRHL                                                    SCIN 584
      SPHS = 100.*SPHS                                                  SCIN 585
      SDHS = 100.*SDHS                                                  SCIN 586
      STHS = 100.*STHS                                                  SCIN 587
      SPHL = 100.*SPHL                                                  SCIN 588
      SDHL = 100.*SDHL                                                  SCIN 589
      STHL = 100.*STHL                                                  SCIN 590
C     CONVERTS WIND SHEAR TO M/S/KM                                     SCIN 591
      DUH = DUH * 1000.                                                 SCIN 592
      DVH = DVH * 1000.                                                 SCIN 593
C      CONVERTS VERTICAL WIND TO CM/S                                   SCIN 594
      WGH = WGH*100.                                                    SCIN 595
      PQA=PQA*100.                                                      SCIN 596
      DQA=DQA*100.
      TQA=TQA*100.
      SPH=SPH*100.
      SDH=SDH*100.
      STH=STH*100.
      PSH=PSH*100.
      DSH=DSH*100.
      TSH=TSH*100.
      IF(NPOP.NE.0) GO TO 920
      UPRE=UGH
      VPRE=VGH
      DUPRE=DUH/1000.
      DVPRE=DVH/1000.
      RETURN
  920 IF (IOPP.NE.0)
     $ WRITE(IOPP,951) H,PHI,THET,PGHP,DGHP,TGH,UGH,VGH,SPH,SDH,STH,
     1SUH,SVH,PGH,DGH,FLOAT(IET),FLOAT(NN),TGHP
  951 FORMAT(F5.1,7F7.2,5F6.2,2E10.3,F5.0,F3.0,F7.2)
      WRITE(6,900) H,PHI,THET,PGH,DGH,TGH,UGH,IWSYM,VGH,PH,DH,TH,UH,
     $ IWSYM,VH,DUH,
     $ DVH,WGH,IET,PGHP,DGHP,TGHP,PHP,DHP,THP,PSH,DSH,TSH,PQ,DQ,TQ,UQ,
     $ VQ,PQA,DQA,TQA,UA,VA,PRHS,DRHS,TRHS,URHS,VRHS,SPHS,SDHS,STHS,
     1SUHS,SVHS,PRHL,DRHL,TRHL,URHL,VRHL,SPHL,SDHL,STHL,SUHL,SVHL,
     2PRH,DRH,TRH,URH,VRH,SPH,SDH,STH,SUH,SVH
  900 FORMAT(1X,F6.2,2F7.2,2(2E9.3,2F6.0,A1,F5.0),2F5.1,23X,F6.2/1X,
     $ I5,14X,2(2( F8.1,'%'),F6.1,'%',11X),10X,
     $3F5.1,10X,' SP',/102X,3F5.1,2F5.0,' QBO'/102X,3F5.1,2F5.0,' MAG'/1
     $02X,3F5.1,2F5.0,' RAMS',/102X,3F5.1,2F5.0,' SIGS',/
     2102X,3F5.1,2F5.0,' RAML',/
     3102X,3F5.1,2F5.0,' SIGL',/
     4102X,3F5.1,2F5.0,' RAMT',/
     5102X,3F5.1,2F5.0,' SIGT',/)
      RETURN
      END
      SUBROUTINE SELEC4
      INTEGER IOTEM2
      COMMON/C4/XL(16),YL(16),NP
C
C     S
C     SUBROUTINE TO SELECT POINTS FOR INTERPOLATION
C
      COMMON /IOTEMP/ IOTEM1,IOTEM2
      COMMON /POINT/ IPT(16,5),LL(16),DXY(16,2)
      COMMON /ORDER/ IPTN(16,5),IREAD(65,3)
C
      DIMENSION               IC(4),IL(2),JL(2),LIML(51),LIMU(51)
C
      DATA  LIML/15,14,13,12,11,10,9,8,7,6,5,4,3,2,23*1,2,3,4,5,6,7,8,9,
     110,11,12,13,14,15/
      DATA  LIMU/33,34,35,36,37,38,39,40,41,42,43,44,45,46,23*47,46,45,
     144,43,42,41,40,39,38,37,36,35,34,33/
      DATA PI/3.14159/
C
C
```

```
C        INITIALIZE
C
      PI4=PI/4.
      DEGRAD=PI/180.
      DO 1 I=1,16
      DO 1 J=1,5
    1 IPT(I,J)=0
C
C        MAJOR LOOP FOR POINTS
C
      DO 100 II=1,NP
C
      LA=ABS(XL(II))*10.+.5
      LO=YL(II)*10.+.5
      LL(II)=LA*10000+LO
      IF (XL(II).LT.0.) LL(II)=-LL(II)
C
      IF (XL(II)-15.1) 15,30,30
   15 IF (XL(II)) 50,40,40
C
C        NMC GRID
C
   30 IPT(II,5)=2
      EL=(350-YL(II))*DEGRAD
      PHI=XL(II)*DEGRAD
      R=31.204359052*(SIN(PI4-PHI/2.)/COS(PI4-PHI/2.))
      XX=R*COS(EL)+24.
      YY=R*SIN(EL)+26.
      I=XX
      J=YY
      DX=XX-I
      DY=YY-J
      DXY(II,1)=DX
      DXY(II,2)=DY
      IF (XL(II).GT.17.18) GO TO 31
      IF ((J.LT.1).OR.(J.GT.51)) GO TO 70
      IF ((I.LT.LIML(J)).OR.(I.GT.LIMU(J))) GO TO 70
   31 IC(1)=I*1000+J
      IF ((ABS(DX).GT..1).OR.(ABS(DY).GT..1)) GO TO 32
      IP=1
      GO TO 35
   32 CONTINUE
      IF (XL(II).GT.17.18) GO TO 34
      IF ((((I.GT.(LIMU(J)-1)).AND.((J.GE.15).AND.(J.LE.37)))
     1 .OR.(J.GT.50)) GO TO 70
      IF ((I+1.GT.LIMU(J+1)).OR.(I.LT.LIML(J+1))) GO TO 80
      IF ((I.EQ.LIMU(J)).OR.(I.EQ.LIML(J))) GO TO 80
   34 IP=4
      IC(2)=(I+1)*1000+J
      IC(3)=I*1000+J+1
      IC(4)=(I+1)*1000+J+1
   35 CONTINUE
      REWIND IOTEM2
      DO 38 IPG=1,1977
      READ(IOTEM2) IJ                                                   SELE  75
      DO 38 K=1,IP                                                      SELE  76
   38 IF(IC(K).EQ.IJ) IPT(II,K)=IPG                                     SELE  77
      GO TO 100                                                         SELE  78
C                                                                       SELE  79
C        EQUATORIAL GRID                                                SELE  80
C                                                                       SELE  81
   40 IPT(II,5)=1                                                       SELE  82
      L1=XL(II)                                                         SELE  83
      L2=YL(II)                                                         SELE  84
      IL(1)=L1/5                                                        SELE  85
      IL(2)=IL(1)+1                                                     SELE  86
      JL(1)=(L2/5)+1                                                    SELE  87
      JL(2)=JL(1)-1                                                     SELE  88
      DO 45 K1=1,2                                                      SELE  89
      DO 45 K2=1,2                                                      SELE  90
      IF ((ABS(XL(II)-IL(K1)*5).GT.0.1).OR.(ABS(YL(II)-JL(K2)*5).GT.0.1)SELE  91
     1 ) GO TO 45                                                       SELE  92
      IF (JL(K2).EQ.72) JL(K2)=0                                        SELE  93
      IPT(II,1)=JL(K2)*4+IL(K1)+1                                       SELE  94
      GO TO 100                                                         SELE  95
   45 CONTINUE                                                          SELE  96
      IF (JL(1).EQ.72) JL(1)=0                                          SELE  97
      IPT(II,1)=JL(1)*4+IL(1)+1                                         SELE  98
      IPT(II,2)=JL(2)*4+IL(1)+1                                         SELE  99
      IPT(II,3)=JL(1)*4+IL(2)+1                                         SELE 100
      IPT(II,4)=JL(2)*4+IL(2)+1                                         SELE 101
      GO TO 100                                                         SELE 102
C                                                                       SELE 103
C        SOUTHERN HEMISPHERE                                            SELE 104
C                                                                       SELE 105
   50 IPT(II,5)=3                                                       SELE 106
      L1=XL(II)                                                         SELE 107
      L2=YL(II)                                                         SELE 108
      IF (ABS(XL(II)).LT.85.0) GO TO 51                                 SELE 109
      IPT(II,1)=1                                                       SELE 110
      IF (ABS(XL(II)+90.).LT.0.11) GO TO 100                            SELE 111
   51 CONTINUE                                                          SELE 112
      IL(1)=(L1/5)-1                                                    SELE 113
      JL(1)=(L2/5)+1                                                    SELE 114
      IL(2)=IL(1)+1                                                     SELE 115
      JL(2)=JL(1)-1                                                     SELE 116
      DO 52 K1=1,2                                                      SELE 117
      DO 52 K2=1,2                                                      SELE 118
      IF ((ABS(XL(II)-IL(K1)*5).GT.0.1).OR.(ABS(YL(II)-JL(K2)*5).GT.0.1)SELE 119
     1  ) GO TO 52                                                      SELE 120
      IF (JL(K2).EQ.72) JL(K2)=0                                        SELE 121
      IPT(II,1)=JL(K2)*17-IL(K1)+1                                      SELE 122
      IF (IL(K).NE.0) GO TO 100                                         SELE 123
      IPT(II,1)=JL(K2)*4+1                                              SELE 124
      IPT(II,5)=1                                                       SELE 125
      GO TO 100                                                         SELE 126
   52 CONTINUE                                                          SELE 127
      IF (JL(1).EQ.72) JL(1)=0                                          SELE 128
      IF (IPT(II,1).EQ.1) GO TO 54
      IPT(II,1)=JL(1)*17-IL(1)+1
      IPT(II,2)=JL(2)*17-IL(1)+1
      IF (IL(2)) 55,53,55
   53 IPT(II,3)=JL(1)*4+1
      IPT(II,4)=JL(2)*4+1
      IPT(II,5)=1133
      GO TO 100
   54 IPT(II,2)=JL(1)*17-IL(2)+1
      IPT(II,3)=JL(2)*17-IL(2)+1
      IPT(II,5)=333
      GO TO 100
   55 CONTINUE
      IPT(II,3)=JL(1)*17-IL(2)+1
      IPT(II,4)=JL(2)*17-IL(2)+1
      GO TO 100
C
C     BODERLINE POINTS
C
   70 CONTINUE
C     TWO NMC, TWO EQUATORIAL
      IPT(II,5)=2211
      L=YL(II)
      IPT(II,1)=((L/5)+2)*4
      IPT(II,2)=IPT(II,1)-4
      IF (L.GE.355) IPT(II,1)=4
C
      IF (J.LT.1) J=1
      IF (J.GT.51) J=51
      IF (I.LT.LIML(J)) I=LIML(J)
      IF (I.GT.LIMU(J)) I=LIMU(J)
      IC(1)=I*1000+J
      IF ((J.LT.15).OR.(J.GT.37)) GO TO 72
      IC(2)=I*1000+J+1
      GO TO 76
   72 IF ((J.NE.1).AND.(J.NE.51)) GO TO 74
      IF (I.EQ.LIMU(J)) GO TO 73
      IC(2)=(I+1)*1000+J
      GO TO 76
   73 IC(2)=(I-1)*1000+J
      GO TO 76
   74 IF (I.EQ.LIML(J)) GO TO 75
      IC(2)=LIMU(J+1)*1000+J+1
      GO TO 76
   75 IC(2)=LIML(J+1)*1000+J+1
C
   76 REWIND IOTEM2
      DO 77 IPG=1,1977
      READ(IOTEM2) IJ
      DO 77 K=1,2
   77 IF(IC(K).EQ.IJ) IPT(II,K+2)=IPG
      GO TO 100
C
   80 CONTINUE
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C     THREE NMC, ONE EQUATORIAL                                         SELE 183
      IPT(II,5)=2212                                                    SELE 184
      IC(2) = 0                                                         SELE 185
      L=YL(II)                                                          SELE 186
      IPT(II,2)=((L/5)+1)*4                                             SELE 187
      IF (L.GE.355) IPT(II,2)=4                                         SELE 188
      IF (I.EQ.LINL(J)) GO TO 84                                        SELE 189
      IF (J.GT.37) GO TO 82                                             SELE 190
      IC(1)=I*1000+J                                                    SELE 191
      IC(3)=I*1000+J+1                                                  SELE 192
      IC(4)=(I+1)*1000+J+1                                              SELE 193
      GO TO 88                                                          SELE 194
   82 IC(1)=(I+1)*1000+J                                                SELE 195
      IC(3)=I*1000+J                                                    SELE 196
      IC(4)=I*1000+J+1                                                  SELE 197
      GO TO 88                                                          SELE 198
   84 IF (J.GT.37) GO TO 86                                             SELE 199
      IC(1)=(I-1)*1000+J+1                                              SELE 200
      IC(3)=I*1000+J+1                                                  SELE 201
      IC(4)=I*1000+J                                                    SELE 202
      GO TO 88                                                          SELE 203
   86 IC(1)=(I+1)*1000+J+1                                              SELE 204
      IC(3)=(I+1)*1000+J                                                SELE 205
      IC(4)=I*1000+J                                                    SELE 206
C                                                                       SELE 207
   88 REWIND IOTEM2                                                     SELE 208
      DO 89 IPG=1,1977                                                  SELE 209
      READ(IOTEM2) IJ                                                   SELE 210
      DO 89 K=1,4                                                       SELE 211
      IF(IC(K).EQ.0) GO TO 89                                           SELE 212
      IF(IC(K).EQ.IJ) IPT(II,K)=IPG                                     SELE 213
   89 CONTINUE                                                          SELE 214
C                                                                       SELE 215
  100 CONTINUE                                                          SELE 216
      DO 150 I=1,16                                                     SELE 217
      DO 150 J=1,5                                                      SELE 218
  150 IPTN(I,J)=IPT(I,J)                                                SELE 219
      CALL SORT4(NP)                                                    SELE 220
      RETURN                                                            SELE 221
      END                                                               SELE 222
      SUBROUTINE SETUP                                                  SETU   1
      COMMON/COTRAN/NDATA(19),IC,MI,IN,IX(10),IEX                       SETU   2
      DIMENSION IP(5),ID(5),IT(5),IDAY(12),BUFFER(64)                   SETU   3
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI,           SETU   4
     .NSAME,RP1L,RD1L,RT1L,SP1L,SD1L,ST1L,RU1L,RV1L,SU1L,SV1L,          SETU   5
     $ MN, IDD, IYR, H1, PHI1R,THETA1R,DUMS(21),RP1S,RD1S               SETU   6
     1,RT1S,RU1S,RV1S,SP1S,SD1S,ST1S,SU1S,SV1S,UDS1,VDS1,               SETU   7
     2UDL1,VDL1,UDS2,VDS2,UDL2,VDL2                                     SETU   8
      COMMON/PDTCOM/IU4,MONTH,IOPR,PG(18,19),TG(18,19),DG(18,19)        SETU   9
     . ,PSP(8,10,12)                                                    SETU  10
     1,DSP(8,10,12),TSP(8,10,12),PAQ(17,5),DAQ(17,5),TAQ(17,5),PDQ(17,5)SETU  11
     2 ,DDQ(17,5),TDQ(17,5),PR(20,10),DR(20,10),TR(20,10),UAQ(17,5)     SETU  12
     3 ,VAQ(17,5),UDQ(17,5),VDQ(17,5),UR(25,10),VR(25,10),              SETU  13
     $ PQ,DQ,TQ,UQ,VQ,PDA,DQA,                                          SETU  14
     .  TBA,UA,VA,IOPQ,PLP(25,10),DLP(25,10),TLP(25,10)                  SETU  15
     1,ULP(25,10),VLP(25,10),UDL(25,10),VDL(25,10),UDS(25,10)            SETU  16
     2,VDS(25,10)                                                        SETU  17
      COMMON/CHIC/DUM(18),IWSYM,UCOEF(14,9),VCOEF(14,9)                  SETU  18
      DIMENSION IDUM(9)                                                  SETU  19
      DATA IDAY/0,31,59,90,120,151,181,212,243,273,304,334/              SETU  20
      XMJD = 0.                                                          SETU  21
      IF (MN.GT.12) GO TO 2                                              SETU  22
      IDA = IDAY(MN) + IDD                                               SETU  23
      DD = IDA                                                           SETU  24
      IF (MOD(IYR,4).EQ.0.AND.MN.GT.2) IDA = IDA + 1                     SETU  25
      XMJD = 2439856. + 365. * (IYR -   68.) + IDA + INT((IYR -   65.)   SETU  26
     $ / 4.)                                                             SETU  27
C.....SECOND DATA CARD READS, FREE FIELD, THE FOLLOWING DATA:             SETU  28
C         IUG = UNIT NUMBER FOR GROVES DATA TAPE                         SETU  29
C         IUR = UNIT NUMBER FOR RANDOM SIGMA DATA                        SETU  30
C                   (IF IUR=IUG UNIT IUG WILL BE READ)                   SETU  31
C         IUQ = UNIT NUMBER FOR QBO DATA                                 SETU  32
C                   (IF IUQ=IUG DATA ON TAPE ON UNIT IUG WILL BE READ)   SETU  33
C         IU4 = UNIT FOR 4-D INPUT P,D,T 0-25KM DATA                     SETU  34
C         IOPR = RANDOM OUTPUT OPTION                                    SETU  35
C.....IOPR=1 RANDOM OUTPUT              IOPR=2 NO RANDOM OUTPUT          SETU  36
C         IOPQ = QBO OUTPUT OPTION                                       SETU  37
C.....IOPQ=1 QBO OUTPUT                 IOPQ=2 NO QBO OUTPUT             SETU  38
C         NR1 = STARTING RANDOM NUMBER                                   SETU  39
C         NMCOP = NMC GRID DATA READ OPTION                              SETU  40
C.....NMCOP=0  READS NMC GRID DATA FROM UNIT IUG, OTHERWISE READS FORM   SETU  41
C         CARDS                                                          SETU  42
C.....IOTEM1=UNIT FOR 4-D P, D, T DATA (SCRATCH FILE, DOES NOT NEED TO   SETU  43
C         BE ASSIGNED)                                                   SETU  44
C.....IOTEM2=UNIT FOR NMC GRID POINTS (SCRATCH FILE, DOES NOT NEED TO    SETU  45
C         BE ASSIGNED)                                                   SETU  46
    2 READ(5,10) IUG,IUR,IUQ,IU4,IOPR,IOPQ,NR1,NMCOP,IOTEM1,IOTEM2       SETU  47
10    FORMAT( )                                                          SETU  48
      WRITE(6,9000) IUG,IUR,IUQ,IU4,IOPR,IOPQ,NR1,NMCOP,IOTEM1,IOTEM2    SETU  49
     $ ,XMJD                                                             SETU  50
      IF (IOPR.LT.1.OR.IOPR.GT.2) GO TO 666                              SETU  51
      IF (IOPQ.LT.1.OR.IOPQ.GT.2) GO TO 666                              SETU  52
      MONTH=MN                                                           SETU  53
      IF (IOPR.EQ.2) GO TO 7                                             SETU  54
      R=RAND(NR1)                                                        SETU  55
      R = RAND(0)                                                        SETU  56
      R = RAND(0)                                                        SETU  57
C.....THIRD DATA CARD READS FREE FIELD, THE FOLLOWING DATAZ               SETU  58
C         RP1 = INITIAL RANDOM PRESSURE PERTURBAIIONS, PERCENT           SETU  59
C         RD1 = INITIAL RANDOM DENSITY PERTURBATION, PERCENT             SETU  60
C         RT1 = INITIAL RANDOM TEMPERATURE PERTURBATION, PERCENT         SETU  61
C         SD1 = INITIAL STANDARD DEVIATION FOR RANDOM DENSITY            SETU  62
C                   PERTURBATION, PERCENT                                SETU  63
C         RU1 = INITIAL EASTWARD WIND PERTURBATION, M/S                  SETU  64
C         RV1 = INITIAL NORTHWARD WIND PERTURBATION, M/S                 SETU  65
C         SU1 = INITIAL STANDARD DEVIATION FOR RANDOM EASTWARD WIND, M/S SETU  66
C         SV1 = INITIAL STANDARD DEVIATION FOR RANDOM NORTHWARD WIND, M/SSETU  67
      READ(5,10) RP1L,RP1S,RD1L,RD1S,RT1L,RT1S,RU1L,RU1S,RV1L,RV1S       SETU  68
      RP1=RP1L+RP1S
      RD1=RD1S+RD1L
      RT1=PT1S+RT1L
      RU1=RU1L+RU1S
      RV1=RV1L+RV1S
C     AVOIDS TAPE SEARCH IF CURRENT MONTH IS SAME AS PREVIOUS MONTH
      IF(NSAME.GT.0) GO TO 621
    7 IF (NSAME.EQ.1) GO TO 621
      CALL GETNMC
C.....LOADS NMC GRID DATA FROM INPUT UNIT TO SCRATCHFILE UNIT IOTEM2
      IF (MONTH.LT.13) GO TO 12
      M1=13
      M2=13
C.....MONTH=13 IS ANNUAL AVERAGE CASE
      GO TO 13
   12 M1=MONTH
      M2=MONTH + 6
C.....SOUTHERN HEMISPHERE DATA IS 6 MONTHS DISPLACED FOR GROVES,
C          STATIONARY PERTURBATIONS, AND RANDOM PERTURBATIONS
      IF (M2.GT.12) M2=M2 - 12
   13 DO 100 I=1,234
      CALL RTRAN1
C.....READS GROVES PRESSURE DATA
      IF (IC.NE.'P') GO TO 666
      IF (MI.EQ.M1) GO TO 30
      IF (MI.EQ.M2) GO TO 40
      GO TO 100
   30 KS=1
      GO TO 50
   40 KS=-1
   50 IH=(IH-20)/5
      TENX=10.**IEX
      DO 60 J=1,10
      K=10+KS*(J-1)
   60 PG(IH,K) = IX(J)*TENX
C.....CONVERSION TO REAL AND STORAGE IN ARRAY COMPLETE
  100 CONTINUE
      DO 200 I=1,234
      CALL RTRAN1
C.....READS GROVES DENSITY DATA
      IF(IC.NE.'D') GO TO 666
      IF (MI.EQ.M1) GO TO 130
      IF (MI.EQ.M2) GO TO 140
      GO TO 200
  130 KS=1
      GO TO 150
  140 KS=-1
  150 IH=(IH-20)/5
      TENX=10.**IEX
      DO 160 J=1,10
      K=10+KS*(J-1)
  160 DG(IH,K) = IX(J)*TENX
C.....CONVERSION TO REAL AND STORAGE IN ARRAY COMPLETE
  200 CONTINUE
```

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      DO 300 I=1,234                                                    SETU 123
      CALL RTRAN1                                                       SETU 124
C.....READS GROVES TEMPERATURE DATA                                     SETU 125
      IF (IC.NE.'T') GO TO 666                                          SETU 126
      IF (NI.EQ.N1) GO TO 230                                           SETU 127
      IF (NI.EQ.N2) GO TO 240                                           SETU 128
      GO TO 300                                                         SETU 129
  230 KS=1                                                              SETU 130
      GO TO 250                                                         SETU 131
  240 KS=-1                                                             SETU 132
  250 IH=(IH-20)/5                                                      SETU 133
      TENX=10.**IEX                                                     SETU 134
      DO 260 J=1,10                                                     SETU 135
      K=10+KS*(J-1)                                                     SETU 136
  260 TG(IH,K) = IX(J)*TENX                                             SETU 137
C.....CONVERSION TO REAL AND STORAGE IN ARRAY COMPLETE                  SETU 138
  300 CONTINUE                                                          SETU 139
      IF (MONTH.LT.13) GO TO 308                                        SETU 140
C.....ANNUAL MEAN CASE - BOTH HEMISPHERES EQUAL                         SETU 141
      DO 304 I=1,18                                                     SETU 142
      DO 304 J=1,9                                                      SETU 143
      J20=20-J                                                          SETU 144
      PG(I,J)=PG(I,J20)                                                 SETU 145
      DG(I,J)=DG(I,J20)                                                 SETU 146
      TG(I,J)=TG(I,J20)                                                 SETU 147
  304 CONTINUE                                                          SETU 148
  308 DO 360 I=1,1248                                                   SETU 149
      CALL RTRAN                                                        SETU 150
C.....READS STATIONARY PERTURBATIONS DATA (TO BE STORED IN PSP, DSP, ANDSETU 151
C        TSP ARRAYS)                                                    SETU 152
      IC=NDATA(1)                                                       SETU 153
      NI=NDATA(2)                                                       SETU 154
      IH=NDATA(3)                                                       SETU 155
      LON=NDATA(4)                                                      SETU 156
      DO 311 K=1,5                                                      SETU 157
      IP(K)=NDATA(4+K)                                                  SETU 158
      ID(K)=NDATA(9+K)                                                  SETU 159
  311 IT(K)=NDATA(14+K)                                                 SETU 160
      IF (IC.NE.'S') GO TO 666                                          SETU 161
      IF (NI.EQ.N1) GO TO 320                                           SETU 162
      IF (NI.EQ.N2) GO TO 330                                           SETU 163
      GO TO 360                                                         SETU 164
  320 KS=1                                                              SETU 165
      GO TO 340                                                         SETU 166
  330 KS=-1                                                             SETU 167
  340 ISH=2+(IH-44)/8                                                   SETU 168
      L=(LON+20)/30                                                     SETU 169
      IF(IH.LT.52) ISH = (IH-20)/10                                     SETU 170
      IF (IH.GT.84) ISH=8                                               SETU 171
      DO 350 J=1,5                                                      SETU 172
      K=5+KS*(J+(KS-1)/2)                                               SETU 173
      PSP(ISH,K,L) = IP(J)/1000.                                        SETU 174
      DSP(ISH,K,L) = ID(J)/1000.                                        SETU 175
  350 TSP(ISH,K,L) = IT(J)/1000.                                        SETU 176
```

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C.....CONVERSION TO REAL AND STORAGE IN ARRAYS COMPLETE                 SETU 177
  360 CONTINUE                                                          SETU 178
      IF (MONTH.LT.13) GO TO 368                                        SETU 179
C.....ANNUAL MEAN CASE - BOTH HEMISPHERES EQUAL                         SETU 180
      DO 364 I=1,8                                                      SETU 181
      DO 364 K=1,12                                                     SETU 182
      DO 364 J=1,5                                                      SETU 183
      J10=11-J                                                          SETU 184
      PSP(I,J,K)=PSP(I,J10,K)                                           SETU 185
      DSP(I,J,K)=DSP(I,J10,K)                                           SETU 186
      TSP(I,J,K)=TSP(I,J10,K)                                           SETU 187
  364 CONTINUE                                                          SETU 188
C     MOVES PAST 2ND EOF ON UNIT IUG                                    SETU 189
368   READ(IUG,9999,END=369) IDUMMY                                     SETU 190
9999  FORMAT(A1)                                                        SETU 191
      GO TO 368                                                         SETU 192
369   CONTINUE                                                          SETU 193
      IF(IOPR.EQ.2) GO TO 440                                           SETU 194
C.....IOPR=1 READS RANDOM SIGMAS,  IOPR=2 ZEROS RANDOM SIGMAS            SETU 195
      DO 430 I=1,260                                                    SETU 196
      IF (IUR.EQ.IUG) GO TO 375                                         SETU 197
      READ (IUR,380) IC,MI,IH,IP,ID,IT                                  SETU 198
C.....USES FORTRAN READ ON UNIT IUR IF IUR NEQ IUG                       SETU 199
  380 FORMAT (1X,A1,I2,I4,3(1X,5I4))                                    SETU 200
      GO TO 385                                                         SETU 201
  375 CALL RTRAN                                                        SETU 202
C.....READS FROM UNIT IUG IF IUG = IUR                                  SETU 203
      IC=NDATA(1)                                                       SETU 204
      MI=NDATA(2)                                                       SETU 205
      IH=NDATA(3)                                                       SETU 206
      DO 381 K=1,5                                                      SETU 207
      IP(K)=NDATA(3+K)                                                  SETU 208
      ID(K)=NDATA(8+K)                                                  SETU 209
  381 IT(K)=NDATA(13+K)                                                 SETU 210
  385 IF (IC.NE.'R') GO TO 666                                          SETU 211
C     M1 = NORTHERN HEMISPHERE MONTH                                    SETU 212
      IF (MI.EQ.M1) GO TO 390                                           SETU 213
C      SOUTHERN HEMISPHERE MONTH                                        SETU 214
      IF (MI.EQ.M2) GO TO 400                                           SETU 215
C.....M2 = M1 + 6   UNLESS M1 = M2 = 13                                 SETU 216
      GO TO 430                                                         SETU 217
  390 KS=1                                                              SETU 218
      GO TO 410                                                         SETU 219
  400 KS=-1                                                             SETU 220
  410  IF (IH.LT.95) IHR=(IH-20)/5                                      SETU 221
C     IHR = HEIGHT INDEX                                                SETU 222
      IF (IH.GE.95) IHR = 14 + (IH - 80) / 20                           SETU 223
      DO 420 J=1,5                                                      SETU 224
      K = 5 + KS * (J + (KS - 1) / 2)                                   SETU 225
C.....K = LATITUDE INDEX 1-5 = LAT -90 TO -10, 6-10 = LAT +10 TO +90    SETU 226
      PR(IHR,K) =(IP(J)/1000.)**2                                       SETU 227
      DR(IHR,K) =(ID(J)/1000.)**2                                       SETU 228
  420 TR(IHR,K) =(IT(J)/1000.)**2                                       SETU 229
  430 CONTINUE                                                          SETU 230
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      IF (MONTH.LT.13) GO TO 460
C.....ANNUAL MEAN CASE - BOTH HEMISPHERES EQUAL
      DO 435 I=1,20
      DO 435 J=1,5
      J10=11-J
      PR(I,J)=PR(I,J10)
      DR(I,J)=DR(I,J10)
      TR(I,J)=TR(I,J10)
  435 CONTINUE
      GO TO 460
  440 DO 450 I=1,20
      DO 450 J=1,10
      PR(I,J) = 0.
      DR(I,J) = 0.
  450 TR(I,J) = 0.
C.....RANDOM SIGMAS ARE ZEROED IF IOPR=2
      DO 455 I=1,25
      DO 455 J=1,10
      UR(I,J)=0.
  455 VR(I,J) = 0.
      GO TO 500
  460 DO 490 I=1,325
      IF (IUR.EQ.IUG) GO TO 462
      READ(IUR,465) IC,MI,IH,IP,ID
C.....READS RANDOM WIND STANDARD DEVIATIONS WITH FORTRAN READ FROM
C        UNIT IUR IF IUR NEQ IUG
  465 FORMAT(1X,A2,I2,I4,2(1X,5I4))
      GO TO 467
  462 CALL RTRAN
C.....READS FROM UNIT IUG IF IUG = IUR
      IC=NDATA(1)
      MI=NDATA(2)
      IH=NDATA(3)
      DO 461 K=1,5
      IP(K)=NDATA(3+K)
  461 ID(K)=NDATA(8+K)
  467 IF (IC.NE.'RW') GO TO 666
C     NORTHERN HEMISPHERE MONTH
      IF (MI.EQ.M1) GO TO 470
C     SOUTHERN HEMISPHERE MONTH
      IF (MI.EQ.M2) GO TO 475
      GO TO 490
  470 KS=1
      GO TO 480
  475 KS=-1
  480 IF (IH.LT.95) IHR=1+IH/5
C     HEIGHT INDEX
      IF (IH.GE.95) IHR=19+(IH-80)/20
      DO 485 J=1,5
C     LATITUDE INDEX
      K=5+KS*(J+(KS-1)/2)
      UR(IHR,K)=(IP(J)**2)*1.
  485 VR(IHR,K)=(ID(J)**2)*1.
  490 CONTINUE
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      IF (MONTH.LT.13) GO TO 500                                        SETU 285
C.....ANNUAL MEAN CASE - BOTH HEMISPHERES EQUAL                         SETU 286
      DO 495 I=1,25                                                     SETU 287
      DO 495 J=1,5                                                      SETU 288
      J10=11-J                                                          SETU 289
      UR(I,J)=UR(I,J10)                                                 SETU 290
      VR(I,J)=VR(I,J10)                                                 SETU 291
  495 CONTINUE                                                          SETU 292
C     MOVES PAST 3RD EOF ON UNIT IUG                                    SETU 293
      IF(IOPR.EQ.2) GO TO 900                                           SETU 294
500   READ(IUG,9999,END=501) IDUMMY                                     SETU 295
      GO TO 500                                                         SETU 296
501   CONTINUE                                                          SETU 297
      DO 840 I=1,25                                                     SETU 298
      IF(IUR.EQ.IUG) GO TO 800                                          SETU 299
      READ(IUR,380) IC,MI,IH,IP,ID,IT                                   SETU 300
C.....USES FORTRAN READ ON UNIT IUR IF IUR NEQ IUG                      SETU 301
      GO TO 820                                                         SETU 302
  800 CALL RTRAN                                                        SETU 303
C.....READS FROM UNIT IUG IF IUR = IUG                                  SETU 304
      IC=NDATA(1)                                                       SETU 305
       MI=NDATA(2)                                                      SETU 306
      IH=NDATA(3)                                                       SETU 307
      DO 810 K=1,5                                                      SETU 308
      IP(K)=NDATA(3+K)                                                  SETU 309
      ID(K)=NDATA(8+K)                                                  SETU 310
  810 IT(K)=NDATA(13+K)                                                 SETU 311
  820 IF(IH.GT.90) IH=70+(IH/4)                                         SETU 312
      IH=1+(IH/5)                                                       SETU 313
      IF(IC.NE.'P'.OR.IH.NE.I) GO TO 666                                SETU 314
      DO 830 J=1,5                                                      SETU 315
      PLP(I,J+5)=IP(J)/1000.                                            SETU 316
       PLP(I,6-J)=IP(J)/1000.                                           SETU 317
      DLP(I,J+5)=ID(J)/1000.                                            SETU 318
      DLP(I,6-J)=ID(J)/1000.                                            SETU 319
      TLP(I,J+5)=IT(J)/1000.                                            SETU 320
  830 TLP(I,6-J)=IT(J)/1000.                                            SETU 321
  840 CONTINUE                                                          SETU 322
      DO 865 I=1,25                                                     SETU 323
      IF(IUR.EQ.IUG) GO TO 845                                          SETU 324
      READ(IUR,465) IC,MI,IH,IP,ID                                      SETU 325
      GO TO 855                                                         SETU 326
  845 CALL RTRAN                                                        SETU 327
      IC=NDATA(1)                                                       SETU 328
      MI=NDATA(2)                                                       SETU 329
      IH=NDATA(3)                                                       SETU 330
      DO 850 K=1,5                                                      SETU 331
      IP(K)=NDATA(3+K)                                                  SETU 332
  850 ID(K)=NDATA(8+K)                                                  SETU 333
  855 IF(IH.GT.90) IH=70+(IH/4)                                         SETU 334
      IH=1+(IH/5)                                                       SETU 335
      IF(I.NE.IH.OR.IC.NE.'PW') GO TO 666                               SETU 336
      DO 860 J=1,5                                                      SETU 337
      ULP(I,J+5)=IP(J)/1000.                                            SETU 338
      ULP(I,6-J)=IP(J)/1000.
      VLP(I,J+5)=ID(J)/1000.
  860 VLP(I,6-J)=ID(J)/1000.
  865 CONTINUE
      DO 888 I=1,25
      IF(IUR.EQ.IUG) GO TO 870
      READ(IUR,868)IC,MI,IH,IP,ID
 868  FORMAT(1X,A2,I2,I4,2(1X,5I5))
      GO TO 880
  870 CALL RTRAN
      IC=NDATA(1)
      MI=NDATA(2)
      IH=NDATA(3)
      DO 875 K=1,5
      IP(K)=NDATA(3+K)
  875 ID(K)=NDATA(8+K)
  880 IF(IH.GT.90) IH=70+(IH/4)
      IH=1+(IH/5)
      IF(IH.NE.I.OR.IC.NE.'CS')GO TO 666
      DO 885 J=1,5
      UDS(I,J+5)=(IP(J)/1000.)
      UDS(I,6-J)=(IP(J)/1000.)
      VDS(I,J+5)=(ID(J)/1000.)
  885 VDS(I,6-J)=(ID(J)/1000.)
  888 CONTINUE
      DO 898 I=1,25
      IF(IUR.EQ.IUG) GO TO 890
      READ(IUR,868)IC,MI,IH,IP,ID
      GO TO 894
  890 CALL RTRAN
      IC=NDATA(1)
      MI=NDATA(2)
      IH=NDATA(3)
      DO 892 K=1,5
      IP(K)=NDATA(3+K)
  892 ID(K)=NDATA(8+K)
  894 IF(IH.GT.90) IH= 70+(IH/4)
      IH=1+(IH/5)
      IF(IH.NE.I.OR.IC.NE.'CL') GO TO 666
      DO 996 J=1,5
      UDL(I,J+5)=(IP(J)/1000.)
      UDL(I,6-J)=(IP(J)/1000.)
      VDL(I,J+5)=(ID(J)/1000.)
  896 VDL(I,6-J)=(ID(J)/1000.)
  898 CONTINUE
      GO TO 910
  900 DO 905 I=1,25
      DO 905 J=1,10
      PLP(I,J)=0.
      HLP(I,J)=0.
      TLP(I,J)=0.
      ULP(I,J)=0.
      VLP(I,J)=0.
      UDS(I,J)=0.
      UDL(I,J)=0.                                                       SETU 393
      VDS(I,J)=0.                                                       SETU 394
      VDL(I,J)=0.                                                       SETU 395
  905 CONTINUE                                                          SETU 396
C.....MOVES PAST NEXT EOF ON TAPE                                       SETU 397
      IF (IOPQ.EQ.2) GO TO 600                                          SETU 398
910   READ(IUG,9999,END=911) IDUMMY                                     SETU 399
      GO TO 910                                                         SETU 400
911   CONTINUE                                                          SETU 401
C.....IOPQ=1 READS QBO PARAMETERS,  IOPQ=2 ZEROS THESE PARAMETERS        SETU 402
      DO 530 I=1,16                                                     SETU 403
      IF (IUQ.EQ.IUG) GO TO 525                                         SETU 404
      READ(IUQ,520) IC,IH,IX                                            SETU 405
C.....READS WITH FORTRAN FROM UNIT IUQ IF IUQ NEQ IUG                    SETU 406
  520 FORMAT (1X,A2,I3,5(I4,I5))                                        SETU 407
      GO TO 527                                                         SETU 408
  525 CALL RTRAN2                                                       SETU 409
C.....READS FROM UNIT IUG IF IUQ = IUG                                  SETU 410
  527 IF (IC.NE.'QP') GO TO 666                                         SETU 411
      IH = (IH-5)/5                                                     SETU 412
      DO 530 J=1,5                                                      SETU 413
C.....CONVERT FROM INTEGER PER MIL - QBO PRESSURE AMPLITUDE              SETU 414
      PAQ(IH,J) = IX(2*J-1)/1000.                                       SETU 415
C.....QBO PRESSURE PHASE (DAYS PAST JAN 0, 1966)                        SETU 416
  530 PDQ(IH,J) = IX(2*J)*1.                                            SETU 417
      DO 531 I = 1,5                                                    SETU 418
      PAQ(1,I) = 0.                                                     SETU 419
 531  CALL PHASE(PDQ(2,I),15.,PDQ(3,I),20.,PDQ(1,I),10.)                SETU 420
      DO 540 I=1,16                                                     SETU 421
      IF (IUQ.EQ.IUG) GO TO 535                                         SETU 422
      READ (IUQ,520) IC,IH,IX                                           SETU 423
      GO TO 537                                                         SETU 424
  535 CALL RTRAN2                                                       SETU 425
  537 IF (IC.NE.'QD') GO TO 666                                         SETU 426
      IH=(IH-5)/5                                                       SETU 427
      DO 540 J=1,5                                                      SETU 428
C...CONVERT FROM INTEGER PER MIL - QBO DENSITY AMPLITUDE                 SETU 429
      DAQ(IH,J) = IX(2*J-1)/1000.                                       SETU 430
C.....QBO DENSITY PHASE (DAYS PAST JAN 0, 1966)                         SETU 431
  540 DDQ(IH,J)=IX(2*J)*1.                                              SETU 432
      DO 541 I = 1,5                                                    SETU 433
      DAQ(1,I) = 0.                                                     SETU 434
 541  CALL PHASE(DDQ(2,I),15.,DDQ(3,I),20.,DDQ(1,I),10.)                SETU 435
      DO 550 I=1,16                                                     SETU 436
      IF (IUQ.EQ.IUG) GO TO 545                                         SETU 437
      READ (IUQ,520) IC,IH,IX                                           SETU 438
      GO TO 547                                                         SETU 439
  545 CALL RTRAN2                                                       SETU 440
  547 IF (IC.NE.'QT') GO TO 666                                         SETU 441
      IH = (IH- 5)/5                                                    SETU 442
      DO 550 J=1,5                                                      SETU 443
C.....CONVERTS FROM INTEGER PER MIL - QBO TEMPERATURE AMPLITUDE          SETU 444
      TAQ(IH,J) = IX(2*J-1)/1000.                                       SETU 445
C.....QBO TEMPERATURE PHASE                                             SETU 446
```

```
  550 TDQ(IH,J) = IX(2*J)*1.
      DO 551 I = 1,5
      TAQ(1,I) = 0.
  551 CALL PHASE(TDQ(2,I),15.,TDQ(3,I),20.,TDQ(1,I),10.)
      DO 560 I=1,16
      IF (IUQ.EQ.IUG) GO TO 555
C.....READS WITH FORTRAN IF IUQ NEQ IUG
      READ(IUQ,520) IC,IH,IX
      GO TO 557
  555 CALL RTRAN2
C.....READS FROM UNIT IUG IF IUQ = IUG
  557 IF (IC.NE.'QU') GO TO 666
      IH=(IH- 5)/5
      DO 560 J=1,5
C.....EASTWARD WIND QBO AMPLITUDE - CONVERTED TO M/S
      UAQ(IH,J) = IX(2 * J - 1) / 10.
C.....EASTWARD WIND QBO PHASE (DAYS PAST JAN 0, 1966)
  560 UDQ(IH,J)=IX(2*J)*1.
      DO 561 I = 1,5
      UAQ(1,I) = 0.
  561 CALL PHASE(UDQ(2,I),15.,UDQ(3,I),20.,UDQ(1,I),10.)
      DO 570 I=1,16
       IF (IUQ.EQ.IUG) GO TO 565
      READ(IUQ,520) IC,IH,IX
      GO TO 567
  565 CALL RTRAN2
  567 IF (IC.NE.'QV') GO TO 666
      IH=(IH- 5)/5
      DO 570 J=1,5
C.....NORTHWARD WIND QBO AMPLITUDE - CONVERTED TO M/S
      VAQ(IH,J) = IX(2 * J - 1) / 10.
C.....NORTHWARD WIND QBO PHASE (DAYS PAST JAN 0,1966)
  570 VDQ(IH,J)=IX(2*J)*1.
      DO 571 I = 1,5
      VAQ(1,I) = 0.
  571 CALL PHASE(VDQ(2,I),15.,VDQ(3,I),20.,VDQ(1,I),10.)
      GO TO 611
  600 DO 610 I=1,IUG
      DO 610 J=1,5
      PAQ(I,J) = 0.
      DAQ(I,J) = 0.
      TAQ(I,J) = 0.
      PDQ(I,J) = 0.
      DDQ(I,J) = 0.
      TDQ(I,J) = 0.
      UAQ(I,J)=0.
      UDQ(I,J)=0.
      VAQ(I,J)=0.
      VDQ(I,J)=0.
  610 CONTINUE
C.....MOVE PAST NEXT EOF ON TAPE.
  611 READ(IUG,9999,END=609) IDUMMY
      GO TO 611
609   CONTINUE
```

```
C...READ IN SPHERICAL HARMONICS COEFFICIENTS.....................
      DO 615 IFR=1,MM
      DO 613 JFR=1,14
      READ(IUG,640)IF1,IF2,(IDUM(I),I=1,9)
  640 FORMAT(2X,19I7)
      DO 613 I=1,9
 613  UCOEF(JFR,I)=FLOAT(IDUM(I))/100.
      DO 612 JFR=1,14
      READ(IUG,640)IF1,IF2,(IDUM(I),I=1,9)
      DO 612 I=1,9
 612  VCOEF(JFR,I)=FLOAT(IDUM(I))/100.
 615  CONTINUE
C.....ZEROS QBO PARAMETERS IF IOPQ = 2
C.....REWINDS TAPE UNIT IUG
      REWIND IUG
C
 621  R=H1
      IF(H1.LT.25.) R=25.
      CALL RTERP(R ,PHI1,PR,DR,TR,SP1,SD1,ST1)
      CALL INTRUV(PLP,DLP,H1,PHI1,PLP1,DLP1)
      CALL INTRUV(TLP,DLP,H1,PHI1,TLP1,R)
      SP1L=SQRT(PLP1*ABS(SP1))*100.
      SP1S=SQRT((1.-PLP1)*ABS(SP1))*100.
      SD1L=SQRT(DLP1*ABS(SD1))*100.
      SD1S=SQRT((1.-DLP1)*ABS(SD1))*100.
      ST1L=SQRT(TLP1*ABS(ST1))*100.
      ST1S=SQRT((1.-TLP1)*ABS(ST1))*100.
      CALL INTRUV(UR,VR,H1,PHI1,SU1,SV1)
      CALL INTRUV(ULP,VLP,H1,PHI1,ULP1,VLP1)
      SU1L=SQRT(ULP1*ABS(SU1))
      SU1S=SQRT((1.-ULP1)*ABS(SU1))
      SV1L=SQRT(VLP1*ABS(SV1))
      SV1S=SQRT((1.-VLP1)*ABS(SV1))
      CALL INTRUV( UDL,VDL,H1,PHI1,UDL1,VDL1)
      CALL INTRUV(UDS,VDS,H1,PHI1,UDS1,VDS1)
      UDL1=UDL1*100.
      VDL1=VDL1*100.
      UDS1=UDS1*100.
      VDS1=VDS1*100.
      WRITE(6,9001) RP1L,RD1L,RT1L,SP1L,SD1L,ST1L,RU1L,RV1L,SU1L,SV1L,
     1'LARGE'
      WRITE(6,9001)RP1S,RD1S,RT1S,SP1S,SD1S,ST1S,RU1S,RV1S
     1,SU1S,SV1S,'SMALL'
      WRITE(6,9002)UDL1,VDL1,UDS1,VDS1
      WRITE(6,9003)
      RP1L=RP1L/100.
      RD1L=RD1L/100.
      RT1L=RT1L/100.
      SP1L=(SP1L/100.)
      SD1L=(SD1L/100.)
      ST1L=(ST1L/100.)
      RP1S=RP1S/100.
      RD1S=RD1S/100.
      RT1S=RT1S/100.
      SP1S=SP1S/100.                                                    SETU 555
      SD1S=SD1S/100.                                                    SETU 556
      ST1S=ST1S/100.                                                    SETU 557
      UDL1=UDL1/100.                                                    SETU 558
      VDL1=VDL1/100.                                                    SETU 559
      UDS1=UDS1/100.                                                    SETU 560
      VDS1=VDS1/100.                                                    SETU 561
      WRITE(6,630)                                                      SETU 562
      RETURN                                                            SETU 563
  666 WRITE(6,700) IUG,IUR,IUD,IOPR,IOPO,NR1,NMCOP,IOTEM1,IOTEM2,       SETU 564
     $MONTH,IC,MI,IH,IX,IEX,IP,ID,IT,SD1                                SETU 565
  700 FORMAT(' ERROR IN SETUP INPUT',/,1X,5I3,I10,4I3,A2,I3,I4,/,11I4,  SETU 566
     $/,15I4,/,F10.1)                                                   SETU 567
      STOP                                                              SETU 568
  630 FORMAT(27X,'UNPERTURBED (MONTHLY MEAN)',11X,'MEAN PLUS PERTURBATIOSETU 569
     1NS',9X,'THERMAL',/,23X,2(34('-'),2X),3X,'WIND',6X,'PERTURBATION VASETU 570
     2LUES',/,' HEIGHT   LAT    WEST   PRES.    DENS.   TEMP  GEOSTROPH.SETU 571
     3  PRES.    DENS.   TEMP     TOTAL      SHEAR',/,2X,'(KM)',11X,'LOSETU 572
     4N',4X,'(NT/      (KG/    (DEG  WIND (M/S)   (NT/      (KG/    (DEG  SETU 573
     5WIND (M/S)  (M/S/KM) ',28('-'),/,' TIME    (DEG)  (DEG)',2('   M**SETU 574
     62)    M**3)   KEL-  ',10('-')),2X,8('-'),'  P    D    T    U    V SETU 575
     7  M'/' (SEC)',35X,'VIN)   E-W   N-S',20X,'VIN)   E-W   N-S  E-W  NSETU 576
     8-S (%)  (%)  (%)  M/S  M/S CM/S'/)                                SETU 577
 9000 FORMAT('  GROVES INPUT UNIT = ',I2,T43,'RANDOM INPUT UNIT = ',I2, SETU 578
     1T83,'OBO INPUT UNIT = ',I2,/,'  4-D INPUT UNIT = ',I2,T43,'RANDOM SETU 579
     2OPTION = ',I2,T83,'OBO OPTION = ',I2,/,'  FIRST RANDOM NUMBER = ',SETU 580
     2I5,                                                               SETU 581
     3/,'  NMC READ OPTION = ',I2,T43,'4-D P,D,T DATA SCRATCH UNIT = ', SETU 582
     4I2,/,'  NMC GRID POINTS SCRATCH UNIT = ',I2,T43,'JULIAN DATE = ', SETU 583
     5F9.1,/)                                                           SETU 584
 9001 FORMAT('  INITIAL P,D,T = ',3(F6.2,' %   '),T60,'SIGMA P,D,T = ', SETU 585
     13(F6.2,' %   '),/,'  INITIAL U,V = ',2(F7.2,' M/S   '),T60,'SIGMA SETU 586
     2U,V = ',2(F7.2,' M/S   '),  7X,A5,1X,'SCALE'/)                    SETU 587
 9003 FORMAT(//'  **  PERCENT DEVIATIONS FROM 1962 US STANDARD '        SETU 588
     1 ,'ATMOSPHERE APPEAR BELOW PRESSURE, DENSITY AND TEMPERATURE ',   SETU 589
     2 'VALUES  **'//)                                                  SETU 590
 9002 FORMAT('  INITIAL UDL,VDL = ',2(F6.2,' % '),                      SETU 591
     1T60,'INITIAL UDS,VDS = ',2(F6.2,' % '))                           SETU 592
      END                                                               SETU 593
      SUBROUTINE SORTA(NP)                                              SORT   1
C                                                                       SORT   2
C               SORTS POINTS FOR SEQUENTIAL TAPE READING                SORT   3
C                                                                       SORT   4
C         ASSIGNS POINT NUMBERS BY ORDER ON TAPE, NOT BY GRID           SORT   5
C                                                                       SORT   6
      COMMON /ORDER/ IPT (16,5),IREAD(65,3)                             SORT   7
C                                                                       SORT   8
      DO 1 I=1,65                                                       SORT   9
      DO 1 J=1,3                                                        SORT  10
    1 IREAD(I,J)=0                                                      SORT  11
      DO 9 I=1,NP                                                       SORT  12
      IF(IPT(I,5).LT.1) GO TO 10                                        SORT  13
      IF(IPT(I,5).EQ.1) GO TO 9                                         SORT  14
      IF(IPT(I,5).EQ.2) GO TO 2                                         SORT  15
      IF(IPT(I,5).EQ.3) GO TO 4
      IF(IPT(I,5).EQ.1133)GO TO 6
      IF(IPT(I,5).EQ.2211) GO TO 7
      IF(IPT(I,5).EQ.2212)GO TO 8
      IF (IPT(I,5).EQ.333) GO TO 4
      GO TO 10
    2 DO 3 J=1,4
      IF(IPT(I,J).LT.1) GO TO 3
      IPT(I,J)=IPT(I,J)+288
    3 CONTINUE
      GO TO 9
    4 DO 5 J=1,4
      IF(IPT(I,J).LT.1) GO TO 5
      IPT(I,J)=IPT(I,J)+2265
    5 CONTINUE
      GO TO 9
    6 IF(IPT(I,1).GT.0)IPT(I,1)=IPT(I,1)+2265
      IF(IPT(I,2).GT.0)IPT(I,2)=IPT(I,2)+2265
      GO TO 9
    7 IF(IPT(I,3).GT.0)IPT(I,3)=IPT(I,3)+288
      IF(IPT(I,4).GT.0)IPT(I,4)=IPT(I,4)+288
      GO TO 9
    8 IF(IPT(I,1).GT.0)IPT(I,1)=IPT(I,1)+288
      IF(IPT(I,3).GT.0)IPT(I,3)=IPT(I,3)+288
      IF(IPT(I,4).GT.0)IPT(I,4)=IPT(I,4)+288
    9 CONTINUE
C
C         REORDERS POINT NUMBERS FOR READ
C
   10 IR=0
      DO 13 K=1,NP
      DO 13 L=1,4
      MP=IPT(K,L)
      IF(MP.LT.1) GO TO 13
   11 II=K
      JJ=L
      DO 12 I=1,NP
      DO 12 J=1,4
      IF (IPT(I,J).LT.1) GO TO 12
      IF(IPT(I,J).GT.3490) GO TO 12
      IF(IPT(I,J).GE.MP) GO TO 12
      II=I
      JJ=J
      MP=IPT(I,J)
   12 CONTINUE
      IF(IPT(II,JJ).GT.3490) GO TO 14
      IR=IR+1
      IREAD(IR,1)=II
      IREAD(IR,2)=JJ
      IREAD(IR,3)=IPT(II,JJ)
      IPT(II,JJ)=IPT(II,JJ)+9000
      MP=IPT(K,L)
      IF(MP.GT.3490) GO TO 13
      GO TO 11
   13 CONTINUE                                                          SORT  70
   14 RETURN                                                            SORT  71
      END                                                               SORT  72
      SUBROUTINE SPHERE(MN,IH,PHIR,THETR,US,VS)                         SPHE   1
      COMMON/CHIC/DUM(18),IWSYM,UCOEF(14,9),VCOEF(14,9)                 SPHE   2
      DIMENSION Z(9)                                                    SPHE   3
      COSPHI=COS(PHIR)                                                  SPHE   4
      COSTHET=COS(THETR)                                                SPHE   5
      SINPHI=SIN(PHIR)                                                  SPHE   6
      SINTHET=SIN(THETR)                                                SPHE   7
      Z(1)=1.                                                           SPHE   8
      Z(2)=SINPHI                                                       SPHE   9
      Z(3)=COSTHET*COSPHI                                               SPHE  10
      Z(4)=SINTHET*COSPHI                                               SPHE  11
      Z(5)=(3*(SINPHI**2)-1)/2.                                         SPHE  12
      Z(6)=COSTHET*(3*COSPHI*SINPHI)                                    SPHE  13
      Z(7)=SINTHET*(3*COSPHI*SINPHI)                                    SPHE  14
      Z(8)=(2*(COSTHET)**2-1)*(3*(COSPHI)**2)                           SPHE  15
      Z(9)=(2*SINTHET*COSTHET)*(3*(COSPHI)**2)                          SPHE  16
5     IH5=IH/5-4                                                        SPHE  17
      IFR=9                                                             SPHE  18
      IF(IH.GT.65)IFR=4                                                 SPHE  19
      US=0.                                                             SPHE  20
      VS=0.                                                             SPHE  21
      DO 10 I=1,IFR                                                     SPHE  22
      US=US+Z(I)*UCOEF(IH5,I)                                           SPHE  23
      VS=VS+Z(I)*VCOEF(IH5,I)                                           SPHE  24
10    CONTINUE                                                          SPHE  25
      RETURN                                                            SPHE  26
      END                                                               SPHE  27
      SUBROUTINE STDATM(Z,T,P,D)                                        STDA   1
      DIMENSION ZS(35),TMS(35),WMS(35),PS(35)                           STDA   2
      DATA (ZS(I),I=1,35)/0., 11.019, 20.063, 32.162, 47.35,            STDA   3
     * 52.429, 61.591, 79.944, 90., 95., 100., 105., 110., 115.,        STDA   4
     * 120., 135., 150., 155., 160., 165., 170., 180., 190., 210.,      STDA   5
     * 230., 265., 300., 350., 400., 450., 500.,550.,600., 650., 700./  STDA   6
      DATA (TMS(I),I=1,35)/288.15, 216.65,216.65, 228.65, 270.65,270.65,STDA   7
     * 252.65, 180.65, 180.65, 0., 210.65, 0., 260.65, 0., 360.65,      STDA   8
     * 0., 960.65, 0., 1110.65, 0., 1210.65, 0., 1350.65, 0., 1550.65,  STDA   9
     * 0., 1830.65, 0., 2160.65, 0., 2420.65, 0., 2590.65, 0.,          STDA  10
     * 2700.65/                                                         STDA  11
      DATA (WMS(I),I=1,35)/28.9644, 28.9644, 28.9644, 28.9644, 28.9644, STDA  12
     * 28.9644, 28.9644, 28.9644, 28.9644, 28.94, 28.88, 28.75, 28.56,  STDA  13
     * 28.32, 28.07, 27.37, 26.92, 26.79, 26.66, 26.52, 26.45, 26.15,   STDA  14
     * 25.85, 25.27, 24.69, 23.67, 22.66, 21.24, 19.94, 18.82, 17.94,   STDA  15
     * 17.29, 16.84, 16.50, 16.17/                                      STDA  16
      DATA (PS(I),I=1,35)/1013.25, 226.32, 54.7487, 8.68014, 1.10905,   STDA  17
     * .590005, .182099, 1.0377E-2, 1.6438E-3, 0., 3.0075E-4, 0.,       STDA  18
     * 7.3544E-5, 0., 2.5217E-5, 0., 5.0617E-6, 0., 3.6943E-6, 0.,      STDA  19
     * 2.7926E-6, 0., 1.6852E-6, 0., 6.9604E-7, 0., 1.8838E-7, 0.,      STDA  20
     * 4.0304E-8, 0., 1.0957E-8, 0., 3.4502E-9, 0., 1.1918E-9/          STDA  21
      IF(Z.LT.0.) GO TO 91                                              STDA  22
      RO=6356.36                                                        STDA  23
      GO=9.8066                                                         STDA  24
```

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```
      WMO=28.9644
      RS=8314.32
      ZM=Z*1000.
      ROM=6356360.
      IF(Z.GE.90.) GO TO 6
      DO 3 I=1,8
      IF(ZS(I).LE.Z.AND.Z.LT.ZS(I+1)) GO TO 5
    3 CONTINUE
    5 ZL=INT(ZS(I))*1.
      ZU=INT(ZS(I+1))*1.
      ZLM=ZL*1000.
      ZUM=ZU*1000.
      IF(I.EQ.8) ZU=88.743
      WM=WMO
      HT=(RO*Z)/(RO+Z)
      HM=HT*1000.
      G=(TMS(I+1)-TMS(I))/(ZU-ZL)
      GM=G*.001
      IF(G.LT.0..OR.G.GT.0.) GO TO 12
      P=PS(I)*EXP(-(GO*WMO*(HM-ZLM))/(RS*TMS(I)))*100.
      GO TO 13
   12 P=PS(I)*((TMS(I)/(TMS(I)+G*(HT-ZL)))**((GO*WMO)/(RS*GM)))*100.
   13 T=TMS(I)+G*(HT-ZL)
      GO TO 25
    6 DO 7 I=9,33,2
      IF(ZS(I).LE.Z.AND.Z.LT.ZS(I+2)) GO TO 8
    7 CONTINUE
   81 T=0.
      P=0.
      D=0.
      RETURN
    8 ZL=ZS(I)
      ZU=ZS(I+2)
      ZLM=ZL*1000.
      ZUM=ZU*1000.
      ZMID=ZS(I+1)
      AO=WMS(I)
      A2=-2.*(2.*WMS(I+1)-WMS(I+2)-AO)/((ZU-ZL)**2.)
      A1=(WMS(I+2)-AO-A2*((ZU-ZL)**2.))/(ZU-ZL)
      WM=AO+A1*(Z-ZL)+A2*((Z-ZL)**2.)
      G=(TMS(I+2)-TMS(I))/(ZS(I+2)-ZS(I))
      GM=G*.001
      TK=ZLM-(TMS(I)/GM)
      S=(WMO*GO*ROM*ROM)/(RS*GM)
      A=((ROM+ZM)*(ZLM-TK)/((ZM-TK)*(ROM+ZLM)))
      B=(S/((TK+ROM)**2.))
      P=PS(I)*(((ROM+ZM)*(ZLM-TK)/((ZM-TK)*(ROM+ZLM)))**(S/((TK+ROM)
     1**2.)))*EXP((-S*(ZLM-ZM))/((TK+ROM)*(ZM+ROM)*(ZLM+ROM)))*100.
      TM=TMS(I)+G*(Z-ZS(I))
      T=(WM/WMO)*TM
   25 D=(WM*P)/(RS*T)
   26 RETURN
      END
      SUBROUTINE TINF
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI,
     .          NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,
     $ MN, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,GI,
     .   IHR,MIN,NMORE,DX,HL,VL,DZ
      COMMON/COMJAC/XLAT,XLONG,SDA,SHA,DY,R,TE,EM
C
C   SUROUTINE TINF CALCULATES THE EXOSPHERIC TEMPERATURE ACCORDING TO JA
C     SAO NO. 313 ,1970.
C
C LIST
C     F10 = SOLAR RADIO NOISE FLUX (XE-22 WATTS/M**2)
C     F10B= 81-DAY AVERAGE F10
C     GI  = GEOMAGNETIC ACTIVITY INDEX,AP
C     LAT = GEOGRAPHIC LATITUDE AT PERIGEE  (IN RAD)
C     SDA = SOLAR DECLINATION ANGLE         (IN RAD)
C     SHA = SOLAR HOUR ANGLE
C     DY  = D/Y (DAY NUMBER/TROPICAL YEAR)? 1
C     R = 0.31  (DIURNAL FACTOR)
C
C   CONSTANTS -- C=SOLAR ACTIVITY VARIATION. BETA,ETC. = DIURNAL VARIATI
C                D=GEOMAGNETIC VARIATION. E=SIMIANNUAL VARIATION.
C
      C1 = 383.0
      C2 =   3.32
      C3 =   1.80
C
      PI = 3.14159265
      CON = 0.01745329252
      BETA= -37.0*CON
      GAMMA= 43.0*CON
      P   =   6.0*CON
      XM  =   2.5
      XNN =   3.0
C
      D1 =  28.0
      D2 =   0.03
      D3 =   1.0
      D4 = 100.0
      D5 =  -0.08
C
      E1 =   2.41
      E2 =   0.349
      E3 =   0.206
      E4 = 360.*CON
      E5 = 226.5*CON
      E6 = 720.*CON
      E7 = 247.6*CON
      E8 =   0.1145
      E9 =   0.5
      E10= E4
      E11= 342.3*CON
      E12=  2.16
C
C SOLAR ACTIVITY VARIATION
```

```
C
      TC = C1 + C2*F10B + C3*(F10 - F10B)
C
C DIURNAL VARIATION
C
      ETA    = 0.5*ABS(XLAT - SDA)
      THETA  = 0.5*ABS(XLAT + SDA)
      TAU    = SHA + BETA + P*SIN(SHA + GAMMA)
      TPI=2*PI
      IF(TAU) 210,230,230
  210 IF(TAU+PI) 220,250,250
  220 TAU=TAU+TPI
      GO TO 210
  230 IF(TAU-PI) 250,250,240
  240 TAU=TAU-TPI
      GO TO 230
  250 CONTINUE
      A1 =(SIN(THETA))**XM
      A2 =(COS(ETA))**XM
      A3 =(COS(TAU/2.))**XNN
      B1 = 1.0 + R*A1
      B2 =(A2-A1)/B1
      TV = B1*( 1. + R*B2*A3)
      TL = TC*TV
C
C GEOMAGNETIC VARIATION
C
      TG = D3*GI + D4*(1-EXP(D5*GI))
C
C SEMIANNUAL VARIATION
C
      G3 = 0.5*(1.0 + SIN(E10*DY +E11) )
      G3 = G3**E12
      TAU1 = DY + E8*(G3 - E9)
      G1 = E2 + E3*(SIN(E4*TAU1 + E5))
      G2 = SIN(E6*TAU1+ E7)
      TS = E1 + F10B*G1*G2
C
C EXOSPHERIC TEMPERATURE
C
      TE = TL + TG + TS
      RETURN
      END
      SUBROUTINE TME
      COMMON/COMJAC/XLAT,XLONG,SDA,SHA,DY,R,T,EM
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI,
     .          NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,
     $ MM, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,AP,
     .   IHR,MIN,NMORE,DX,HL,VL,DZ
C
C LIST
C INPUT
C    MM=MONTH.  IDA=DAY. IYR=YEAR. HR = HOUR.  MIN = MINUTE
C    XLAT = LATITUDE (INPUT-GEOCENTRIC LATITUDE.)
```

```
C     XLONG= LONGITUDE(INPUT-GEOCENTRIC LONGITUDE. OUTPUT   -180 TO + 180)
C OUTPUT
C     SDA = SOLAR DECLINATION ANGLE (IN RAD)
C     SHA = SOLAR HOUR ANGLE (IN RAD)
C     DD  = DAY NUMBER FROM 1JAN.
C     DY  = DD/TROPICAL YEAR
C
C
C SET CONSTANTS
C
      YEAR = 365.2422
      YR=IYR
    6 DY = DD/YEAR
   30 FMJD = XMJD - 2435839.
C
C  COMPUTE GREENWICH MEAN TIME IN MINUTES GMT
C
      XHR =IHR
      XMIN = MIN
      GMT = 60*XHR + XMIN
C
C  COMPUTE GREENWICH MEAN POSITION - GP (IN DEG)
C
      XJ = (XMJD - 2415020.0)/(36525.0)
      A1=99.6909833
      A2 = 36000.76854
      A3 = 0.00038708
      A4 = 0.25068447
      GP = A1 + A2*XJ + A3*XJ*XJ + A4*GMT
      N = GP/360.
      XN = N
      GP = GP - XN*360.
C
C  COMPUTE RIGHT ASCENSION POINT - RAP (IN DEG)
C
C     1ST CONVERT GEOCENTRIC LONGITUDE TO DEG LONGITUDE - WEST NEG $ EAST
C
      IFACT = XLONG/180.
      XFACT = IFACT
      XLONG = 360. * XFACT - XLONG
C
      RAP = GP + XLONG
      N = RAP/360.
      XN = N
      RAP = RAP - XN*360.
C
C  COMPUTE CELESTIAL LONGITUDE - XLS (IN RAD) - -PI/2 TO +PI/2
C
      B1 = 0.017203
      B2 = 0.0335
      B3 = 1.410
      Y1 = B1*FMJD
      XLS = Y1 + B2*SIN(Y1) - B3
      TPI = 6.28318
      N = XLS/TPI                                                       TME   66
      XN = N                                                            TME   67
      XLS = XLS - XN*TPI                                                TME   68
C                                                                       TME   69
C  COMPUTE SOLAR DECLINATION ANGLE - SDA (IN RAD)                       TME   70
C                                                                       TME   71
      B4 = (TPI/360.)*23.45                                             TME   72
      SDA = ASIN(SIN(XLS)*SIN(B4))                                      TME   73
C                                                                       TME   74
C  COMPUTE RIGHT ASCENSION OF SUN - RAS (IN RAD) - -PI/2 TO +PI/2       TME   75
C                                                                       TME   76
      RAS = ASIN(TAN(SDA)/TAN(B4))                                      TME   77
C                                                                       TME   78
C  PUT RAS IN SAME QUADRANT AS XLS                                      TME   79
C                                                                       TME   80
      PI = 3.14159265                                                   TME   81
      PI2 = PI/2.                                                       TME   82
      PI32= 3.*PI2                                                      TME   83
      RAS = ABS(RAS)                                                    TME   84
      TEMP = ABS(XLS)                                                   TME   85
      IF(TEMP - PI2) 130,130,100                                        TME   86
  100 IF(TEMP - PI) 105,105,110                                         TME   87
  105 RAS = PI - RAS                                                    TME   88
      GO TO 130                                                         TME   89
  110 IF(TEMP - PI32) 115,115,120                                       TME   90
  115 RAS = PI + RAS                                                    TME   91
      GO TO 130                                                         TME   92
  120 RAS = TPI - RAS                                                   TME   93
  130 IF (XLS) 135,140,140                                              TME   94
  135 RAS = -RAS                                                        TME   75
  140 CONTINUE                                                          TME   96
C                                                                       TME   97
C  COMPUTE SOLAR HOUR ANGLE - SHA (IN DEG) - -                          TME   98
C                                                                       TME   99
      SHA = RAP*(PI/180.) - RAS                                         TME  100
      IF(SHA) 210,230,230                                               TME  101
  210 IF(SHA+PI) 220,250,250                                            TME  102
  220 SHA=SHA+TPI                                                       TME  103
      GO TO 210                                                         TME  104
  230 IF(SHA-PI) 250,250,240                                            TME  105
  240 SHA=SHA-TPI                                                       TME  106
      GO TO 230                                                         TME  107
  250 CONTINUE                                                          TME  108
C                                                                       TME  109
      RETURN                                                            TME  110
      END                                                               TME  111
      SUBROUTINE WIND                                                   WIND   1
      COMMON /WINCOM/RHO,FCORY,DX5,DY5,PX,PY,PXX,PXY,PYY,U,V,  T,TX,TY, WIND   2
     $   DU,DV,P,UPRE,VPRE,DUPRE,DVPRE                                  WIND   3
      COMMON /IOTEMP/DUM1(7),PHI,DUM2(11),MM,DM2A(5),G,R,H,PHIR,        WIND   4
     $THETR,DUM3(15),FLAT                                               WIND   5
      COMMON/CHIC/DUM(18),IWSYM,UCOEF(14,9),VCOEF(14,9)                 WIND   6
      ABSPHI=ABS(PHI)                                                   WIND   7
      IF (RHO.GT.0..AND.ABSPHI   .GT.0.) GO TO 20                       WIND   8
      U = 0.
      V = 0.
      IF(ABSPHI  .LE.0) GO TO 31
      RETURN
 20   FCORX = FCORY*DX5/DY5
      U = - PY/(FCORY*RHO)
      V =   PX/(FCORX*RHO)
      DU = -(G*TY)/(FCORY*T)
      DV =  (G*TX)/(FCORX*T)
  31  IF(H.GT.20.AND.H.LT.95.)GOTO 99
      IF(ABSPHI.GE.FLAT) RETURN
      U=UPRE
      V=VPRE
      DU=DUPRE
      DV=DVPRE
      RETURN
C...SPHERICAL HARMONICS SECTION.....................................
  99  IH=INT(H)
      IF(IH.LE.25)GOTO 130
      IF(IH.GE.90)GOTO 140
      IH1=5*INT(H/5.)
      IH2=IH1+5
      CALL SPHERE(MN,IH1,PHIR,THETR,US,VS)
      CALL SPHERE(MN,IH2,PHIR,THETR,US2,VS2)
      FACS=(H-IH1)/5.
      U=US+(US2-US)*FACS
      V=VS+(VS2-VS)*FACS
      DU=(US2-US)/5000.
      DV=(VS2-VS)/5000.
      RETURN
C...LOW ALTITUDE FAIRING
  130 CALL SPHERE(MN,25,PHIR,THETR,US,VS)
      FACS=(H-20.)/5.
      FACG=1.-FACS
      U=FACG*U+FACS*US
      V=FACG*V+FACS*VS
      CALL SPHERE(MN,30,PHIR,THETR,US2,VS2)
      DUS=(US2-US)/5000.
      DVS=(VS2-VS)/5000.
      RETURN
C...HIGH ALTITUDE FAIRING
  140 CALL SPHERE(MN,90,PHIR,THETR,US,VS)
      FACS=(H-90.)/5.
      FACG=1.-FACS
      U=FACS*U+FACG*US
      V=FACS*V+FACG*VS
      CALL SPHERE(MN,85,PHIR,THETR,US2,VS2)
      DUS=(US-US2)/5000.
      DVS=(VS-VS2)/5000.
      DU=FACG*DU+FACS*DUS
      DV=FACG*DV+FACS*DVS
      RETURN
      END
```

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APPENDIX E

SUMMARY OF PROGRAM CHARACTERISTICS
(Program Operating Environment)

1. Hardware

   a. Computer - Univac 1108 (implemented at Georgia Tech on the CDC Cyber 74 System)

   b. Core Requirements - Approximately 80K on the Georgia Tech CDC. The CDC System routines require more core than the Univac routine so there is no comparison between the system. See Section 5.1.

   c. Mangetic Tapes - All 4-D data tapes are 7 tracks. Proper and SCIDAT data tapes are 9 track. Tapes required are:

      1 program tape (if the program is stored in UNIVAC COPOUT tape format), 1 "SCIDAT" data tape (see Section 4.2), from 1 to 4 4-D data tapes, depending on the number of months to be used under control of one run card (see Section 4.1 and Appendix B).

   d. Card Punch - not required unless optional card output is desired.

   e. Plotter - none required

   f. Drum or Disk - 2 temporary drum or disk files are required. No permanent drum or disk files are created by a program run unless optional non-print output is generated as a permanent disk or drum file.

   g. Other Hardware - none

2. Software

   a. Operating System - UNIVAC EXEC 8 (Georgia Tech version is CDC Nos 1.3)

   b. Language - FORTRAN IV (UNIVAC FORTRAN V)

   c. Type of Run - Batch

   d. Library Subroutines - NTRAN and FLD are UNIVAC subroutines. NTRAN reads 36 bit binary integer woods records. FLD manipulates word bits and is used to break up 4-D data tape 36 bit words into two 18 bit integer words.

   e. Program Overlays - (Optional) - see Section 5.1

3. Program Specifications

   a. Common - See Sections 5.2 - 5.4

3. Program Specifications (cont'd.)

b. Program Segments - See Sections 5.2 - 5.4

c. Program Subroutines - See Section 5.1

d. Listing - See Appendix D

e. Flow Charts - See Figures 5.1, 5.2, 5.3

f. Sample Input - See Appendix C.

g. Sample Output - See Appendix C.

h. Diagnostic Messages - See Section 4.5

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16. ABSTRACT

This report describes recent improvements in the Global Reference Atmospheric Model (NASA TM X-64871 and 64872), originally developed as a global scale (all latitudes and longitudes) model from surface to orbital altitudes. The basic model includes monthly mean values of pressure, density, temperature, and geostrophic winds, as well as quasi-biennial and small-scale and large-scale random perturbations. The newer version reported here incorporates a spherical harmonic wind model for the height range 25-90 km. Parameters for the model were determined from wind data determined by Meteorological Rocket Network soundings, and by grenade releases at higher altitudes. For all latitudes and longitudes in the 25-90 km height range, winds are evaluated by the new spherical harmonic model. Below 25 km and above 90 km, the GRAM program continues to use the geostrophic wind equations and data for pressure, in order to compute the mean wind. Another new feature of the program is that, in the altitudes where the geostrophic wind relations are used, an interpolation scheme is employed for estimating winds at low latitudes, where the geostrophic wind relations begin to mesh down. Several sample wind profiles are given, as computed by the new spherical harmonic wind model.

17. KEY WORDS
Global Atmospheric Model
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